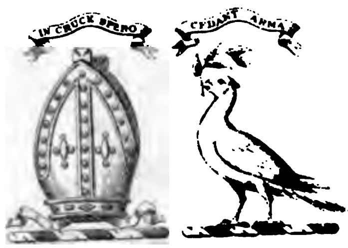

Francis Hubert Barclay

VI

PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

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OF THE

GEOLOGISTS' ASSOCIATION.

VOLUME THE SIXTH.

1879–1880.

EDITED BY J. LOGAN LOBLEY, F.G.S., &c.

(Authors alone are responsible for the opinions and facts stated in their respective Papers.)

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PROCEEDINGS

OF THE

GEOLOGISTS' ASSOCIATION.

ORDINARY MEETING, July 5th, 1878.

Prof. Morris, F.G.S., President, in the Chair.

The Donations to the Library since the previous meeting were announced.

The following were elected Members of the Association:—

John Badcock, jun., Esq.; G. G. Butler, Esq., B.A., Schol. Trin. Col. Camb.; Thomas Benjamin Linley, Esq.; William J. Spratling, Esq.; Sydney Webb, Esq.

The following Paper was read:—

A Geological Sketch of the Boulonnais.

By Dr. Charles Barrois, Member of the Geologists' Association.

CONTENTS:

§ 1. Introduction: Physical Features.

Boulonnais is a country of high interest for geologists. Few districts afford such a variety of fossiliferous formations in so restricted a space, few have a more complete geological literature

resulting from the glorious struggle for progress of geologists on both sides of the Channel. Having often been in Boulonnais, and having derived much benefit from the labours of others, I would be glad if a *résumé* of these would make the Excursion of the Geologists' Association to that district next August more profitable.

It was Rozet, a French officer of the Ordnance Survey, who first called attention to the physical features of Lower Boulonnais; Conybeare and Phillips then acknowledged the relations of this district with the WEALDEN DENUDATION, and considered it as the eastern extension of this anticlinal region. Lower Boulonnais is, generally speaking, an undulating plain, bounded by Chalk hills on the north, east, and south, forming the Upper Boulonnais; on the west it is bounded by the sea. The whole of this Lower Boulonnais area forms a great amphitheatre, on the outside rim of which the Chalk, covered by clay with flints, runs in bold escarpment, forming, as said, the Upper Boulonnais. In the Lower Boulonnais the major part of the surface is occupied by Lower Secondary and Palæozoic beds, the Lower Cretaceous rocks occupying only a narrow border at the foot of the Chalk escarpment, and capping the hills in the interior.

There can be no more doubt in Lower Boulonnais than in the Weald of Kent, that the Chalk and the underlying Cretaceous formations originally extended across all the area. This vast mass of sediment, many hundreds of feet thick, has been swept away by the combined wasting power of the Tertiary seas and atmospheric agencies. The "denudation of the Weald," and, consequently, of "Lower Boulonnais," where the same agencies were at work, has given rise to such theorising by distinguished authors that it would be useless to add anything. I have already given, in 1876, a general account* of the views of Martin, Hopkins, Lyell, S. Wood, Godwin-Austen, Prestwich, Whitaker, Ramsay, and Topley on the subject, and added some supplementary personal observations.

The rocks which are found in Boulonnais are of very different ages—Palæozoic, Jurassic, Cretaceous, and Post-Tertiary; an examination of the district by the aid of my friend Douvillé's geological map will show how completely the contours and scenery

* "Sur la Dénudation des Wealds et le Pas-de-Calais" ("Annales Soc. Géol. du Nord," Vol. iii., p. 75).

have been determined by the presence of beds of different degrees of hardness, and of varying susceptibility to denuding forces.

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1826. *W. H. Fitton:* General Description of the Lower Boulonnais ("Proceed. Geol. Soc.," Vol. i., p. 6).

1828. — *Rozet:* Description Géognostique du Bas-Boulonnais.

1830. — *Rozet:* Notice Géognostique sur les Ardennes et la Belgique ("Annal. des Sciences Natur.").

1834. — *E. Robert:* Note sur le Boulonnais ("Bull. Soc. Géol. de France, 1re Ser., T. iv., p. 312).

1836. *Dr. W. H. Fitton:* On the Strata below the Chalk ("Transac. Geol. Soc.," Ser. 2, Vol. iv., p. 326).

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1839. Réunion Extraordinaire de la Société Géologique de France à Boulogne-sur-mer ("Bull. Soc. Géol. de France," 1re Ser., Vol. x., p. 389).

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—— *Dr. W. H. Fitton:* Lettres à Constant Prévost sur la Géologie du Boulonnais ("Bull. Soc. Géol. de France," 1re Ser., Vol. x., p. 440).

1840. *Sir R. I. Murchison:* Sur les Roches Dévoniennes du Boulonnais et des Pays Limitrophes ("Bull. Soc. Géol. de France," 1re Ser., Vol. xi., p. 229).

1845. — *W. Hopkins:* On the Geological Structure of the Wealden District and of the Bas-Boulonnais ("Trans. Geol. Soc.," Ser. 2, Vol. vii., p. 1).

1851. *Prof. J. Prestwich:* On the Drift at Sangatte Cliff, near Calais ("Quart. Journ. Geol. Soc.," Vol. vii., p. 274).

1852. *Delanoue:* Des Terrains Paléozoiques du Boulonnais et de leurs rapports avec ceux de la Belgique (" Bull. Soc. Géol. de France," 2 ser., Vol. ix., p. 399).

1853. *R. A. C. Godwin-Austen:* On the Series of Upper Palæozoic Groups in the Boulonnais ("Quart. Journ. Geol. Soc.," Vol. ix., p. 231).

—— *D. Sharpe:* Note and List of Fossils of Upper Palæozoic Groups in the Boulonnais (" Quart. Journ. Geol. Soc.," Vol. ix., p. 246).

1856. *R. A. C. Godwin-Austen:* On the Possible Extension of the Coal Measures beneath the S.E. part of England (" Quart. Journ. Geol. Soc.," Vol. xii., p. 38).

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1863. *Lehon:* Sur les Couches Néocomiennes et Albiennes de Wissant (" Bull. Soc. Géol. de France," 2 ser., vol. xxi., p. 14).

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1868. *W. Topley:* On the Lower Cretaceous Beds of the Boulonnais ("Quart. Journ. Geol. Soc.," Vol. xxiv., p. 472).

1870. *E. Pellat:* Notice sur le Boulonnais ("Bull. Soc. Geol. de France," 2e Ser., Vol. xxvii., p. 681).

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1877. *Potier and de Lapparent:* Rapports sur les Sondages exécutés dans le Pas-de-Calais in 1875-76. (Paris, 2 vols., 1875-1877.)

—— *L. Breton:* Etude du terrain-houiler d'Auchy-au-bois, et comparaison avec les terrains du Boulonnais ("Mém. Soc. des Sciences de Lille, T. 3, 5e Ser.).

—— *Chellonneix:* Sur la Position du Belemnites plenus au Blanc-nez ("Annales Soc. Géol. du Nord," T. iv., p. 205, 1877).

1878. *Pellat:* Le T. Jurassique Supérieur du Boulonnais (" Annales Soc. Géol. du Nord," T. v., 1878).
—— *Ch. Barrois:* Memoire sur le T. Crétacé des Ardennes et des Régions comprises entre le Morvan et la Manche (" Annales Soc. Géol. du Nord," T. v., 1878).
—— *E. Rigaux:* The Fossil Brachiopoda of the Lower Boulonnais (" Géol. Mag.")—October, 1878.

Maps.

Du Souich: Carte Géologique du Pas-de-Calais.
Douvillé: Carte Géologique du Boulonnais (No. 3 of the French Geological Survey Map).

§ 3. Palæozoic Rocks.

Rozet described in 1828 the marbles of Boulonnais; and de Verneuil, in 1838, recognised that these Palæozoic marbles were of different ages—the Napoleon marble was equivalent to the Mountain-Limestone, the Ferques marble to the Silurian. In the year 1840 Sir R. Murchison studied the ancient rocks of Boulonnais and their characteristic fossils; he placed the last mentioned marble in his newly established Devonian system. In 1839, M. du Souich remarked that the Coal Measures at Hardinghen were overlaid by the Mountain Limestone; and Sir R. Murchison accepted that the Boulonnais coal was older than the overlying Mountain Limestone.

In 1853 appeared Godwin-Austen's fundamental paper on the Palæozoic Rocks of Boulonnais; it opened a new era in the history of the geology of the country. For Mr. Godwin-Austen says the Boulonnais coal is comprised between two great limestone series, but he differs from all the previous authors on the subject in correlating the Boulonnais coal with that of Belgium and with England's true Coal Measures. He was so led to compare the Napoleon marble which covers it with the Magnesian Limestone.

D. Sharpe, in a note following Godwin-Austen's remarkable paper, adopts, on the contrary, Sir R. Murchison's opinion. The presence of coal between the two limestones appears to him a similar fact to that described long since by Phillips in Yorkshire.

So two different opinions were proposed: the first defended by Sir R. Murchison, E. de Beaumont, Delanoue, and Sharpe, and the other by Godwin-Austen. For the former the Boulonnais coal was

of Mountain Limestone age, for the latter it was of Carboniferous age, and covered by an upper limestone (Magnesian Limestone).

Godwin-Austen's opinion was near the truth as established by Prof. Gosselet's exhaustive work on the subject; Boulonnais coal is of true Carboniferous age, as pointed out by Godwin-Austen, but the overlying limestone is not Magnesian Limestone; it must be correlated with the underlying Carboniferous Limestone, it is upturned by a fault (see Fig. 2). It would be as difficult to explain this stratigraphical feature as it would have been to understand it, without looking for its key and explanation in the Ardennes, where Prof. Gosselet found it out. Consequently it seems necessary to give at first some general information on the great Palæozoic district of which Boulonnais is an isolated part: I think this paragraph of my paper worthy of special attention, on account of the relations indicated by M. Godwin-Austen, Prof. Prestwich, and Prof. Gosselet, between the Boulonnais, Belgian, and Somersetshire Coal-fields, and their importance concerning the search for coal in the South of England. I had the good fortune to accompany Prof. Gosselet some years ago, when he was mapping the Palæozoic district of Boulonnais; and hence I hope the following lines will be found an exact *résumé* of his papers on the subject;* they agree on the principal points with M. Godwin-Austen and Prof. Prestwich's suggestive views.

In the region we are about to describe the Devonico-Carboniferous sediments have been deposited in a very long tract, extending from east to west, in Prussia, North of France, and a part of Southern England.

This sort of long valley was limited to the north by a higher country, which constituted a very important table-land composed of Silurian strata, and which extended northward by Liège, Namur, Tournay, Lille, and Caffiers; it is named the *Brabant Table-land.*

The southern boundary of the marshy region was another *table-land* composed of Cambrian beds, and nearly parallel to the former. It bears the name of *Table-land of the Ardennes.*

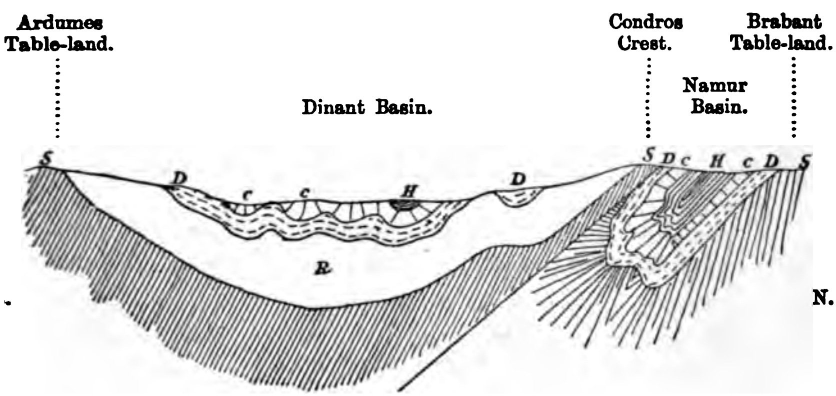
A crest of Silurian formation (*the Condros Crest*) has been

* A paper on the French Northern Coal-field has recently been issued in the "Transactions of the North of England Institute of Mining and Mechanical Engineers," April, 1878, p. 143, by Henry Laporte. Perhaps it will not be unnecessary to state that this paper does not contain any new observation or original view on the geology of the North of France; it is an incomplete *résumé* of some of Prof. Gosselet's geological papers.

recognised by Prof. Gosselet, and traced by several isolated inliers across the whole length of the country, which it divides into two parts: to the north is the *Namur synclinal*, to the south the *Dinant synclinal basin*. This *Condros Crest* crosses Belgium, North of France, and England, where it separates the Devonshire from the Somersetshire basin; the latter would correspond to the *Namur Basin*. Similar comparisons have been enunciated by Mr. R. A. Godwin-Austen and Prof. Prestwich between the flexures of the Pembrokeshire Coal-field and those of the Somersetshire Coal-field along the base of the Mendip Hills, with the flexures of the Franco-Belgian coal-trough.

The Devonico-Carboniferous deposits were interrupted and ended by a great movement in this part of the world, which pushed the southern table-land to the north, while the Brabant table-land stood firm. In consequence of this, the sediments which had been deposited in the intermediate depressions, and which were originally horizontal, or nearly so, were thrown up, compressed and folded, so that the section of the strata became as shown in the adjoined section :—

FIG. 1. (v)



S Silurian. *R* Rhenan or Devonian inferior. *D* Middle and Upper Devonian.
C Carboniferous Limestone. *H* Coal Measures.

The result of the pressure exercised by the southern table-land against the intermediate beds has been that an immense fissure was made all along the coal-field from Liège as far as Marquise, between the *Condros Crest* and the *Namur Basin*. This fissure, the name of which is *the Great Fault* or *Eifelian Fault*, is inclined to

the south, and is like a cleavage along which the *Condros Crest*, while pushed to the north, has been slipped upwards so as to overlie the Coal Measures. This fact explains how Coal Measures are met with under Devonian rocks in Belgium and in France, along the southern limits of the Namur Coal-field.

This Namur Coal-field, of which Boulonnais Coal-field is a continuation, is a synclinal trough. This synclinal may be a regular one, all the beds dipping south, on account of their reversal; or it may be obscured by minor folds or faults running rudely parallel to the principal synclinal line. In Boulonnais, as in every other part of the basin of Namur, the beds north of the synclinal axis which rested on the Brabant table-land, were protected from the southerly pressure by this table-land. On the contrary, the beds south of the synclinal axis were thrown up by this pressure, twisted upon themselves, contorted, broken, and covered very irregularly the coal-seams of the northern half of the synclinal.

Such is the general movement which took place in this region at the close of the Carboniferous Period, and which fully illustrates all the complicated stratigraphical accidents of Boulonnais, as shown by Prof. Gosselet. I think it useless to enter here into any more particulars; the details about the numerous and deep faults, whose intersections transformed the Coal Measures into a series of isolated masses, will be found in Prof. Gosselet's papers already referred to.

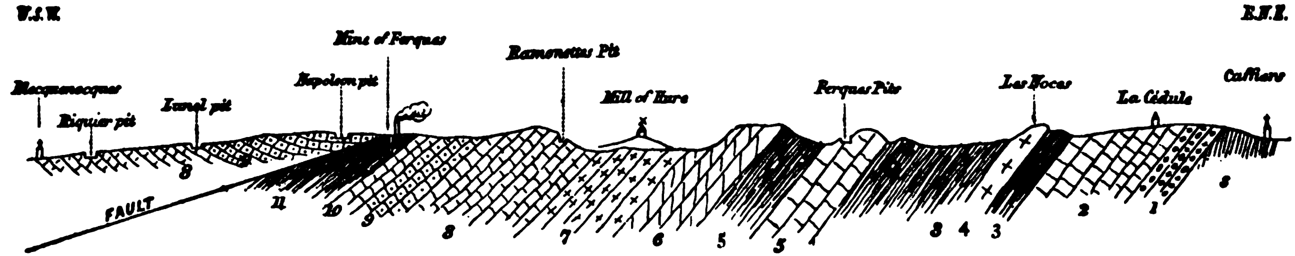
I will now briefly pass in review the succession of the Palæozoic strata of Boulonnais, as traced by Godwin-Austen's and Prof. Gosselet's papers.

The following general section shows the relations of the Palæozoic beds and the succession of strata :—*(See opposite page).*

§. The *Silurian Strata* of Boulonnais are only known by a shaft sunk at Caffiers in a fruitless search for coal; it passed into dark grey shales, containing a fossil which de Verneuil pronounced to be *Graptolites colonus.*

1. The Lower Devonian (T. Rhénan of Dumont) is absent in the Namur-Boulonnais basin; the Silurian is overlaid by beds of Middle Devonian age. These are red shales with conglomerates, they are covered by green micaceous shaly sandstones; in these greenish *Blacourt sandstones* much carbonaceous matter is diffused according to Mr. Godwin-Austen, who found in them impressions of ferns and a portion of a calamite.

SECTION 2. (v.)—SECTION OF THE PALÆOZOIC ROCKS OF BOULONNAIS.



Length about four miles.

North of Blecquenecques are several pits where are quarried a tough violet-bluish limestone, with *Products cora*, and *Lithostrotion* covered by a whitish compact limestone with *Spinifer glaber*, *Productus undatus* (Napoleon marble). These limestones are broken by a fault. The Coal Measures are worked north of the fault, and the seams pass below the Carboniferous Limestone (Napoleon marble) seen before; further north, below the Coal Measures, is found the regular series of the Palæozoic beds. The series of the beds is the following in ascending order:—

S. Silurian.
1. Conglomerates, red shales and green sandstones of Blacourt, ferns, calamites.
2. Blacourt limestones. Orthis striatula, Cyrtina heteroclita, Productus subaculeatus.
3-4. Shales of Beaulieu and Dolomite of les Noces.
5. Ferques limestones, Spirifer Verneuili, S. Bouchardi, Atrypa reticularis, Rhynchonella, Boloniensis, Cyathopyllum hexagonum, Favosites Boloniense.
6. Fiennes sandstone, Cuculloea Hardingii, C. Trapezium, covering red shales and clays.
7. Dolomite of the Hure mill, with crinoidal remains.
8. Haut-banc limestone, with Productus cora.
9. Napoleon marble, with Productus undatus, Spirifer glaber.
10. Limestone, with Productus Giganteus.
11a. The Planes of Hardingehn sandstone (millstone grit), with Productus Flemingii.
11b. Coal Measures of Locquinghen, with Pecopteries Loshii, Sphenopteris coralloides, Sphenophyllum erosum, Annularia radiata, Calamites Suckowii, etc.

2. The *Blacourt Limestone* is a tough, deep blue, and semi-crystalline limestone; it was quarried near the Blacourt and Poussinerie farms. A shaly calcareous band, anciently worked near the Cedule farm, was full of *Favosites*, *Cyathophyllum*, and *Spirifer Bouchardi*. The fauna of this limestone is Middle Devonian (that of Eifelian or Ilfracombe Limestone): *Orthis striatula*, *Spirigera concentrica*, *Atrypa reticularis*, *Cyrtina heteroclita*, *Productus subaculeatus*.

3, 4. *Shales and Dolomites of the Noces.*—These shales are argillaceous, fossiliferous, and contain nodular bands of compact dolomite projecting above the usually level surface of the country, in rude, isolated, and weathered masses.

5. The *Ferques Limestone*, well known by its numerous fossils, is a tough bluish-black limestone, emitting a sulphurous smell when fractured, rather massive in its lower part where it is worked for marble, and more slaty at the top, where it is crowded with fossils. The fauna does not differ much from that of the shales of *Beaulieu* and *les Noces*. This limestone is very extensively worked all along the band, extending from the Fiennes castle to the Eslinghen farm, where M. Gosselet has found the following species:—*Cyrtoceras*, *Spirifer Verneuili*, *S. Bouchardi*, *S. Sauvagei*, *S. Legayi*, *Cyrtina heteroclyta*, *Spirigera concentrica*, *Atrypa reticularis*, *Rhynchonella Boloniensis*, *Productus subaculeatus*, *Orthis striatula*, *O. Dumontiana*, *Streptorynchus umbraculum*, *Leptæna Dutetrii*, *L. Ferquensis*, *Chonetes armata*, *Cyathophyllum hexagonum*, *C. Boloniense*, *C. cæspitosum* var. *A.*, *C. Michelini*, *Tecostegites Bouchardi*, *Favosites Boloniensis*, *Alveolites subæqualis*, *A. suborbicularis*, *Monticulipora Goldfussi*.

6. *Red Shales* and clays overlie the *Ferques Limestone*, as recorded by Godwin-Austen; they constitute but a very unimportant feature in the district. The overlying division of the *Fiennes Sandstones* is of much more interest; the sandstones are fine-grained, yellowish or reddish, micaceous and sometimes calcareous; they are worked for road-metal and as flagstones used for paving purposes. Godwin-Austen has found several fossils: *Cypricardia*, *Bellerophon*, *Cucullæa Hardingii*, *C. trapezium*, *C.* (?) *amygdalina*, which are peculiarly abundant in the St. Godelaine's pits. M. Godwin-Austen has pointed out the identity of this bed with the Marwood Sandstones.

The whole thickness of the Devonian is, according to Prof. Gosselet, about 1830 feet.

The *Carboniferous* or *Mountain Limestone* has been divided, as shown by the Section, Fig. 2, into four divisions by Prof. Gosselet. It must be noted that the lower part of the Carboniferous Series, well known to Palæontologists as the *Tournay Limestone*, is absent in Boulonnais, and the upper part of the Series (or *Visé Limestone*) rests immediately on the Devonian. The Excursion of the Association to North Wales in 1876 had the interesting result of showing that the case was the same in that district; the absence of the *Tournay Limestone* in those regions warrants the supposition of Edward Forbes that the Carboniferous Limestone of most regions was a shallow water deposit.

7. *The Dolomite of the Hure Mill* is the first deposit formed in the Carboniferous sea of Boulonnais. It has a dark cindery-brown colour, is harsh to the touch, becoming sandy in weathering, and is a very dolomitic limestone. It contains in places fragmentary fossil remains, and the disjointed stems of Crinoidea in abundance.

8. *Haut-banc Limestone with Productus cora.*—Massive, grey-reddish and violet coloured limestone, actively worked as marbles, popularly known by the names Henrietta Marble and Coralline Marble; over these marble beds are found the fossil shell *Productus cora*, and several corals, amongst them *Lithostrotion.*

9. *Napoleon Limestone with Productus undatus.*—Massive, greyish-white ore rose-coloured limestones. This marble was used in building the Emperor's column, hence its name. *Spirifer glaber* is the usually found fossil, but Godwin-Austen and *D.* Sharpe have given a full account of its fauna; the species mentioned are—*Terebratula elongata*, *Spirifer glaber*, *Orthis crenistria*, *Chonetes papillonacea*, *Productus undatus*, *P. semireticulatus*, *P. scabriculus*, *P. giganteus* (*auritus*), *Euomphalus pentangulatus*, *Natica antiqua*, *Loxonema sulculosa.* The superposition of this Napoleon limestone on the Haut-banc limestone was duly established by Prof. Gosselet (p. 11); its fauna is the *Visé* fauna.

10. *Limestone with Productus giganteus.*—This limestone is of a black colour at Hardinghen; it is sometimes rendered semi-crystalline by the abundance of the crinoidal stems, and often contains layers of chert gradually merging into the masses of the limestone. The only fossil recorded is the *Productus giganteus.* The celebrated Joinville marble, grey with red veins, is of the same age.

It must be noticed that these palæontological zones of the Boulonnais Mountain Limestone are exactly the same as those of

the Namur Basin, but in this district we find below them the beds of the Tournay Limestone.

11a. *The Plaines of Hardinghen Sandstone* must be correlated with the Millstone Grit; it is a light-brown, gritty, and very micaceous sandstone, which was found resting conformably on the Carboniferous Limestone in the Ferques pit. In these sandstones are found several smaller beds of shales, coal, and limestone. I have found in these Plaines Sandstone *Productus Flemingii, Stigmaria ficoides, Calamites.*

11b. *Coal Measures of Locquinghen.*—They are essentially a shaly formation; amidst the shales there are only a few sandstone bands, the clay-ironstone is rather abundant. There are six distinct bands of Coal Measures in the Boulonnais Coal-field; they are all limited and broken by faults, fully described by Prof. Gosselet. The seams of coal of these bands have been worked, but up to the present time with little profit. The shales associated with the coal-seams contain in abundance remains of Ferns, showing that the vegetation was terrestrial. I have found and identified the following species in the Coal Measure shales at Hardinghen :—*Pecopteris Loshii, Neuropteris heterophylla, Sphenopteris coralloïdes, Trichomanites delicatulus, Sphenophyllum erosum, Annularia radiata, Asterophyllites delicatulus, Calamites Suckowii, C. cystii.*

These plants seem characteristic of a special life-zone in the great coal-field of the North of France; this fact makes it necessary to enter into some details on the mutual relations of the different coal-seams of these coal-fields, though this question leads us to one of those problems of physical geology which yet await solution.

The French northern coal-field affords a remarkable example of the well-known fact that the coal-seams undergo remarkable changes in their extension: while in the north-east of the field the seams are anthracitic, they become semi-bituminous upon reaching the centre of the area, and farther north-west gradually pass into bituminous or gaseous. In the Boulonnais Coal-field the coal is bituminous.

Prof. Gosselet thought that the bituminous coal-seams were the continuation of the anthracitic, and that this alteration in the character of the coal was due to the violent crumplings and contortions the beds had suffered in southern parts of the field, while the anthracitic beds of the northern part remained undis-

turbed.* Thus it was easily understood why the Boulonnais coal was bituminous.

The coal-fields of the Donetz in Southern Russia and that of South Wales present phenomena similar to those here described. In the great coal-field of South Wales, as described by de la Beche and Prof. Hull,† the coal-seams are bituminous to the east, and gradually pass into anthracite at the west of the field. Prof. Hull thinks we must doubtless refer to the agency of a high internal temperature this change in the constitution of the coal-seams. It is a known fact that the temperature increases with the depth; and in the case of the South Wales basin some of the seams have originally been covered by ten or twelve thousand feet of strata, and their temperature, in consequence, raised above that of boiling water. Under such circumstances the gases, we may suppose, would be slowly liberated from the coal-seams, and anthracite would be the result. If such had been also the case in the Northern French basin, we could perhaps account for the difference of chemical constitution of coal in its northern and in its southern parts, by the great facility afforded for the escape of the gaseous products in the northern uncovered part of the coal-field, and by the greater difficulty of their escape in its southern part, when the coal-seams were deeply covered by the upturned and inclined *Condros Crest*, before it was reduced to its present state by denudation.

This explanation fails, however, to explain sufficiently all the differences observed between the coal-seams; thus in Northern Germany, H. Credner‡ has recorded a fact quite opposed to that just described in Northern France; there the undisturbed and horizontal coal-seams are bituminous, while the contorted beds are anthracite, and the more disturbed the more anthracitic. A similar change has been produced in the Alleghany mountains of America, according to Prof. Lesley.

M. Potier§ and afterwards M. Breton‖ have recently put forth a new explanatory theory for the differences of the Northern French coal-seams. According to M. Potier, the Coal Measures in this basin lie unconformably on the Mountain Limestone; the first

* Gosselet: "Etudes sur le Gisement de la Houille dans le Nord," p. 17.

† Prof. Hull: "Coal-fields," London, 1876.

‡ Prof. Hermann Credner: "Elemente der Geologie," French translation by Moniez, of Lille, p. 250.

§ Potier: "Annales de la Soc. Géol.," Vol. iv., p. 166.

‖ Breton: *Id.*, Vol. iv., p. 138.

formed coal-beds were formed in the north-eastern part of the basin, and the deposition of the succeeding beds went on in a subsiding area, gradually extending to the south and to the west. An interesting palæophytological work has been lately issued by the Rev. Abbot Boulay,* who divided the coals of the Northern France Coal-field into the four following zones :—

I.—Zone of very bituminous coal.
II.—Zone of bituminous coal.
III.—Zone of semi-bituminous coal.
IV.—Zone of anthracitic coal.

Each of these lithological divisions is characterised, according to the author, by a particular set of plants; the geological map accompanying the Memoir shows that the lower zone of anthracitic coals (Zone IV.) is only found in the N.E. of the basin, the very bituminous coals (Zone I.) only in the S.W.; this certainly is an important confirmation of M. Potier's views. I don't think, however, these papers really exhaustive, as I find yet many difficulties in the relations of our palæophytological and stratigraphical notions on this coal-field.

This question remains still an open one, and its solution requires much more work to be done. It may be stated in conclusion that the Boulonnais Coal-field belongs on the whole to the bituminous coal (Zone II.) of Rev. Abbot Boulay; its flora, viewed in a more general manner, is that of the Middle Coal Measures of Geinitz and Grand'Eury.

§ 4. Lower Oolites.

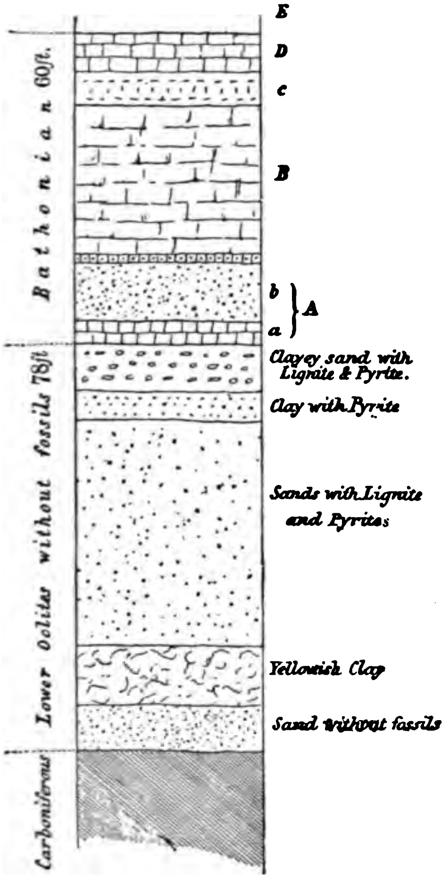
(By Dr. E. Sauvage and E. Rigaux.)

The Bath Oolite of Boulonnais is always found lying immediately above the Palæozoic rocks; it consists of a series of sandy-marly beds, overlaid by compact and oolitic rocks, becoming marly and siliceous at the top. The *Lower Oolites* are best exposed in the neighbourhood of Marquise; the country occupied by the Bathonian forms to the east of that town a small plateau, whose general surface is about 150 feet above the sea level. Situated upon this plateau are a number of Oxfordian outliers; it is also intersected by the Haut-Banc and other sinuous valleys, along the sides of which are exposed Carboniferous inliers. These Bathonian beds

* Rev. Abbot Boulay, D.S., "le Terrain houiller du Nord de la France et ses Végétaux Fossiles." Lille, 1876.

have a general dip towards the west, where they are covered by the Upper Oolites; they rest north and east on the Palæozoic rocks, and are limited on the south by the Slack fault. The Lower Oolites are brought up again farther to the south, by the Wimereux fault, N.W. of Boulogne, at Belle and Bellebrune.

FIG. 3.



The top of the Carboniferous beds, on which were deposited the first Oolitic sediments, are much eroded and pierced by Lithodomi, probably of Oolitic age. No fossils, however, have been found in the immediately overlying beds; they are whitish or greyish sands with ferruginous banding, and occasionally contain lignite, pyrites, and marcasite. The ordinary thickness of the bed is six to twelve feet, but attains 72 feet near Brequeneque (near Marquise).

Over this transitional series the succession of the Bathonian beds, as exhibited at Hydrequent, close to Marquise, is the following, in ascending order:—

		FT.	IN.
(A.) *a.*	Marly limestone, full of *Ostrea Sowerbyi*, *Modiola cf. bipartita*	1	0
	White marl with *Ostrea Sowerbyi*	1	8
	Clayey sand of a red colour	0	10
	Hard limestone full of *Ostrea Sowerbyi*, *Terebratula maxillata*	1	0

		FT.	IN.
b.	Whitish sandy limestone, partly oolitic, with *Rh. concinna, Terebratula obovata* ...	3	4
	Yellow clay	1	0
	Sandy yellowish limestone, harder than below, with *Clypeus Plotii* and numerous Gasteropods: *Alaria lævigata, Natica Stricklandi, Eulima lævigata, Nerinæa Eudesii, Niso Munieri, Cylindrites pyriformis, C. cylindricus, C. cuspidatus*, etc....	3	4
	Whitish fragmentary limestone with large grained oolite, *Terebratula globata, T. obovata, Rhynchonella concinna, Clypeus Plotii, Nerinæa Bathonica*	1	4

The "*Moines*" pits show about 17 feet of a yellowish limestone, in the middle of which is a very fossiliferous bed (*Clypeus Plotii, Holectypus depressus, Rhynchonella depressa, Pecten vagans, Anabacia, Echinobrissus Woodwardi, Nerinea Sharmannii*); this bed seems to be an equivalent of the *Gasteropod limestone.*

		FT.	IN.
(B.)	In the upper part of the undernamed beds, the Oolitic sediments are becoming predominant. The oolitic limestones form here a compact mass of about 30 feet of thickness; there is a bed with *Rhynchonella Hopkinsii, Clypeus Mulleri, Pecten lens, Lima cardiiformis, Hinnites abjectus, Corbis Boloniensis*	25 to 33ft.	
(C.)	The top of B may be seen eroded and bored by Mollusca at the "Calhaudes;" it is covered by a marly limestone with partings of white clay, and burnt for lime. This bed is characterised by *Rhynchonella elegantula, Acrosalenia Lamarckii, Eulima communis*	6	8
(D.)	This bed is specially well exposed in the Bathonian inlier of Belle and Bellebrune. Over C we have the following section:		

	FT.	IN.
Whitish marly limestone, full of small brownish oolites, and very fossiliferous—*Anabacia Bouchardi, Holectypus depressus, Terebratula obovata, T. intermedia, T. lagenalis, T. sublagenalis, Rhynchonella Morieri, Rh. Badensis, Natica ambigua, Trochus inornatus, Cylindrites Thorentii, Pecten Bouchardi, P. vagans, Avicula echinata, Cyprina Loweana, Astarte rotunda, Cypricardia caudata, Myacites securiformis, Pholadomya lyrata,* etc. ...	1	4
Siliceous limestone	1	0
Ferruginous sand with loose oolites and fragments of *Terebratula sublagenalis* ...	0	10
Hard siliceous limestone, eroded and upper surface covered with attached oysters ...	5	0

(E.) Ferruginous marl of the Kelloway Rock, covering the Bathonian on the road from Belle to Cobrique.

The chief division which can be traced in the Lower Oolites of Boulonnais is between the beds B and C of the preceding section; it is marked in the pits by the eroded line formerly indicated. Each of those divisions may also be subdivided in two zones, characterised by the changement of the faunas and of the lithological composition. Considered in a general point of view the Lower Oolites of the district can be divided as follows:—

(A.) Hydrequent Limestone, equivalent of the *Fuller's Earth.*

(B.) Marquise Oolitic Limestone, with *Rhynchonella Hopkinsii,* considered as representative of the siliceous limestone of Minchinhampton. The siliceous limestones and blue clays with broken oysters, forming the basement beds of the Pichottes pits, ought to be looked at as of the same age as the *Marquise limestone,* on account of their similarity with the lower part of the Great Oolite of Enslow Bridge.

(C.) Marly limestone burnt for lime, with *Rh. elegantula,* equivalent of the Forest Marble; it is characterised in Boulonnais by two special forms—*Acrosalenia Lamarckii* and *Rhynchonella elegantula.*

(D.) Siliceous and oolitic limestones of Belle and Bellebrun with *Rhynchonella Badensis*, identical with the English Cornbrash.

These four divisions are very rich in fossils, and have yielded a large suite of species of Mollusca; it can be summed up as follows:—

	Bed D.	Bed C.	Bed B.	Bed A.
Number of species found	160	26	6	95
Species ranging upwards	—	14	3	40
Species ranging downwards ...	39	12	3	—

§ 5. Middle and Upper Oolites (Figs. 1 & 2).

(By M. Edm. Pellat, past-President of the Geological Society of France.)

The *Terrain Jurassique superieur* (Middle and Upper Oolites) comprises in Boulonnais the series of beds situated between the Cornbrash and the Cretaceous. This series may be summed up as follows, in descending order, in the annexed Table.

I value the total thickness of the *Jurassique Superieur* rocks in Boulonnais at 833 feet, but the beds 1 to 7 inclusively, from borings to which I give only 223 feet, seem to attain about 300 feet in the southern part of the Bas-Boulonnais, in the valley of the Liane.

The subdivisions I have introduced in this upper part of the Oolite series are 28 in number, or even 34 in the second column of the Table; the fauna of these subdivisions have already been illustrated in several of my papers;* and their stratigraphical peculiarities have been briefly accounted for in the Annales of the "Société Géologique du Nord."†

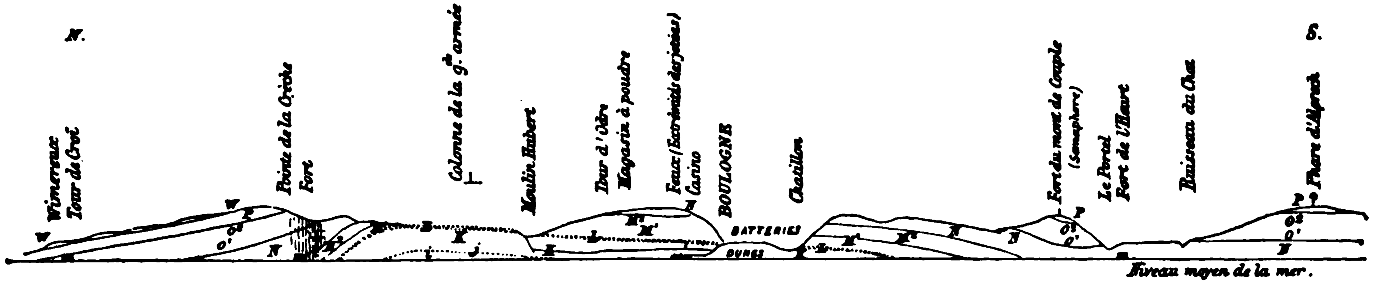
* Pellat et de Loriol "Memoires de la Soc. de Physique et d'Hist. Nat. de Genève."

† Pellat: "Annales de la Soc. Géol. du Nord," Mai, 1878.

TABLE OF THE UPPER JURASSIC ROCKS ...

Lower Kimmer... Zone of Ammo... Orthocera...	15	H	The thirteen beds and small beds of Brequerecque, with *Pholadomya Hortulana*, few and small *Ostrea virgula*	50	0	Lower, Middle, an... and	
Midd...	4		Black clays of le Wast with *Ammonites Rengeri*	20	0	Zone of ... pyrito... Ammon...	Lower C...
Lower Oxfordian (Callovian).	3		Splittery marly limestones of the south of le Wast with *Ammonites Lamberti*........	6	8	Zone of Am. Lamberti.	Oxford Clay.
	2		Clays and sandy limestones at the south of le Wast, with *Ammonites Duncani*, *Serpula vertebralis*	20	0	Zone of Am. Duncani.	
	1		Ferruginous clays of Belle, with *Ammonites Calloviensis* and *Terebratula umbonella*	16	8	Zone of Am. Macro-cephalus.	Kelloway rock.
			(Cornbrash)				
			Approximate thickness of the Upper Jurassic rocks in Boulonnais...	833	4		

FIG. 4.—SECTION SHOWING THE UPPER OOLITES., By M. EDM. PELLAT.



Length about five miles.

Shows the Moulin Hubert Cliff Anticlinal, where are exposed the beds I to M^2. At Wimereux are successively seen beds N to P^4, and the Wealden Sandstones with Unios.

W Sands and ferruginous sandstones, with Unio (Wealden).

P { P^4 Travertine, Cypris bed of Dr. Fitton (Purbeck).
P^3 Siliceous limestones with Cardium dissimile.
P^2 Sands and sandstones, with Natica ceres, Trigonia gibbosa.
P^1 Sands and sandstones, with Trigonia radiata and Serpula coacervata. } Portland Stone.

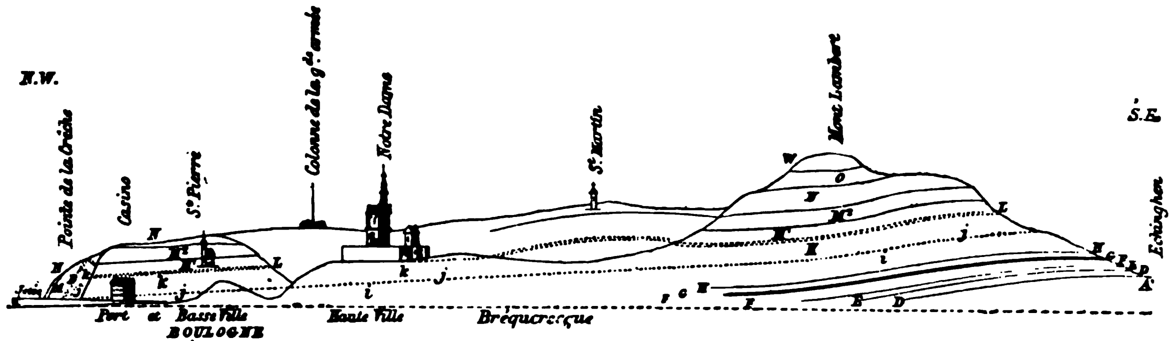
O { O^2 Glauconitic clays, with Ostrea expansa. { Portland Sand.
O^1 Clays with cardium morinicum. { Hartwell

N { N^4 Sandstone with Pterocera oceani.
N^3 Sands with Pernæ.
N^2 Conglomerate with Trigonia Pellati.
N^1 Sandstone with Ammonites portlandicus (gigas).
M^2 Superior shales and limestones of Chatillon. } French Portlandian.

M^1 Inferior shales and limestones of Chatillon, with Ammonites pseudomutabilis.
L Sands and sandstones of Moulin Hubert.
K Superior clays and limestones of Moulin Hubert cliff, with Ammonites caletanus. } Virgulian.

J Sands and sandstones of Conninethun.
I Inferior clays and sandstones of the Moulin Hubert cliff with Ammonites orthoceras.
H See section 2. The 13 beds and small beds of Brequerecque with Pholadomya hortulana. } Pterocerian.

FIG. 5.—SECTION SHOWING THE UPPER AND MIDDLE OOLITES, BY M. EDM. PELLAT.



Length about three miles.

W. Wealden. P to I as in section 1.
H. Thirteen beds and small beds of Brequerecque with Pholadomya hortulana.
G. Sandstone of Wirvigne with Pygurus Jurensis.
F³. Marls, Oolites, and Sandy Limestone of Bellebrune.
F². Clays and Ostrea deltoidea and compact Limestones with Lithodomi.
F¹. Pisolitic Limestone with large Nerineæ of Hesdin-l'Abbé.
E. Siliceous Limestone of Echinghen with Astarte Morini and Trigonia Bronni.
D. Clays of Brucdale with Ostrea deltoidea, of which the Clays with Ostrea deltoidea of the Mount des Boucards appear to be the equivalent.
A'. Coralline Limestone of Brucdale. The Coralline Limestone of the Liane Valley and some limestones below it have probably their equivalents in the North and East of the Boulonnais in the limestones of the Mount des Boucards.

Near le Wast the following beds are seen in descending order:—Limestone of Houllefort with Opis and Pseudomelania Heddingtonensis. Upper beds of the Liégette with Ammonites Martelli and sponges. Clays and Limestones with Terebratula impressa and Millericrinus in the middle beds of the Liégette. Black clays of the north of le Wast, with small pyritous Ammonites, A. Rengeri, etc. Marly splittery limestones of the south of le Wast, with Ammonites Lamberti. Clays and sandy limestones, south of le Wast, with Serpula vertebralis and Ammonites Duncani. Ferruginous clays of the Belle and Alinethun and Ammonites Calloviensis. Cornbrash at Pichottes.

It would seem surprising at first to give distinct names to so very minute divisions of beds, only six or nine feet in thickness. I found it, however, a necessity, and was compelled to have it so by the importance of their fauna, or by stratigraphical considerations.

The whole series of these beds is exceedingly fossiliferous; it has furnished me with more than 6,000 fossils, among which are a great number of new species. Of great and sudden breaks in the succession of life, the beds 9 to 28 exhibit but little evidence; the transition from one fauna to another appears to have been in almost every instance very gradual, and their grouping in stages and sub-stages has been a very arbitrary one. It must also be noted that some forms recur in different beds of distinct ages, but analogous in their lithological characters; the upper parts of the series are specially marked as shallow-water deposits, as attested by the existence of sands, pebbles, and exceedingly variable sediments.

The Upper Jurassic rocks of Boulonnais appear to have more affinities with similar beds in England than with the synchronous formations of the south and east of the Paris Basin.

1. Can only be seen at Belle and in the stream of Alincthun. Several borings have come upon it in other places, where it is represented by a more or less ferruginous clay. (*Ammonites calloviensis*, *Am. plicomphalus*, *Rhynchonella spathica*, &c.)

2, 3. Can only be studied at Le Wast. (*Ammonites Duncani*, *A. Jason*, and very numerous *Serpula vertebralis*.)

4. Is a very constant and well-known palæontological zone; it is met with in Burgundy, Jura, &c., where it always contains small pyritous ammonites of the family of *Am. biplex*, *A. Babeanus*, *A. hecticus*, *A. oculatus*, &c.

5. Is characterised by numerous stems of *Millericrinus* (*M. subechinatus*, *M. ornatus*, *M. calcar*), species everywhere found over the preceding ones.

6. Is important by its fauna, which reminds us of Neuvizy's (Middle-Oxfordian) and Trouville's (Superior Oxfordian) faunas. The *Pseudomelania Heddingtonensis* has been found in the Oxford Oolite. Corallian species are also found in this bed (*Cidaris florigemma* and others). I have considered the bed *a* as a passage-bed between the Oxfordian and Corallian, but it would turn out to be

the lower part of the Superior Oxfordian, if 7, with which it is so intimately connected, is brought into the Oxfordian.

7 (A, B, C, Mount des Boucards Limestone). Here is a question still undecided. The only exposures of this limestone are in the N. and in the E. of Boulonnais, where it is overlaid by the beds 9, 10, 11, &c. In the south of Boulonnais (Liane's valley) wells have been sunk in limestone considered of the same age as these, but here they were underlying a coral reef 66 feet thick, of undoubtedly Corallian age. This corallian bed, 8A′, overlaid in the Liane's valley by 9, 10, 11, may be an isolated and local coral reef, represented in the north of the district by the top of bed 7; or it may be the only representative of the Corallian formation; this would then be absent in the north, when 7 should be included in the Upper Oxfordian.

9 D. Clays with *Ostrea deltoïdea* begins the Kimmeridgian series.

It seems difficult to leave the following beds (from 10 to 14) with the Corallian rocks:

10 E. Full of *Gervillia tetragona*, *Astarte Michaudiana*, *Isodonta Kimmeridgiensis*, &c., and other species of the lower beds of le Havre;

11 F^1. Bed in which lived again some *Nerineæ* of the Inferior Coralline Oolite of the Paris Basin, with a truly Kimmeridgian fauna;

12 F^2. With many *Ostrea deltoïdea*;

13 F^3. Where the Kimmeridge character of the fauna is more strongly marked again—*Trigonia papillata*, *Arca texta*, &c.;

14 G. Sands and grits with *Pygaster umbrella* and rare Corallian fossils, accompanied by *Trigonia papillata*, *Lucina rugosa*, *Pygurus Jurensis*, *Rhabdocidaris Orbignyana*.

The beds 15, 16, are the typical Pterocerians beds, the zone of *Ammonites orthoceras*; the *Ostrea virgula* and *Gervillia tetragona* are very numerous in 16.

In 17, Sands and grits recur.

In 18, Recurrence of black limestone and clays full of *Ostrea virgula*, but where is only found *Ammonites caletanus*.

In 19, Recurrence of sands and grits with shelly limestone formed of Trigoniæ of the family of *gibbosa* (*T. variegata*).

20 M^1. Is the inferior part of a new black clayey series.

21 M². Upper part of the above. I thought it at first of Virgulian age, but place it at present in the overlying series with 22 N¹. 23 N², N³, N⁴, because it contains *Ammonites Portlandicus* (*gigas*), with a part of fauna 24·0¹.

22, 23. Are nearly entirely formed of sands and sandstones, and seem to be unknown in England. Fitton and some other geologists have wrongfully correlated them with 26 and 27; they represent the typical Portlandian of the French geologists—the Portlandian which forms the top of the Jurassic series of Yonne, and which is covered in the east of France by the vacuolar oolite (Purbeck).

24·O¹. 25·0². Are the last beds of black clays; in them was found the interesting fauna found by Sæmann at Hartwell in the Upper Kimmeridge.

25·O². Is full of *Ostrea expansa*; it is a very sandy and glauconitic bed, and appears the equivalent of the English Portland Sand.

26, 27. Contain the most characteristic forms of the English Portland Stone. These beds, with *Natica elegans*, *Trigonia gibbosa*, *Cardium dissimile*, &c., which I consider marine deposits, should be correlated with beds containing *Cyrenæ*, pointing to more littoral conditions. These beds with *Cyrenæ* are siliceous or clayey limestones; they are sometimes ferruginous, and have then been referred to the Wealden. The Boulonnais and Bray districts are the only two regions of the Paris Basin where the equivalents of the English Portland Stone have ever been noticed. It is absent in the east and the south of that Basin. In 27, are some species of the Purbeck.

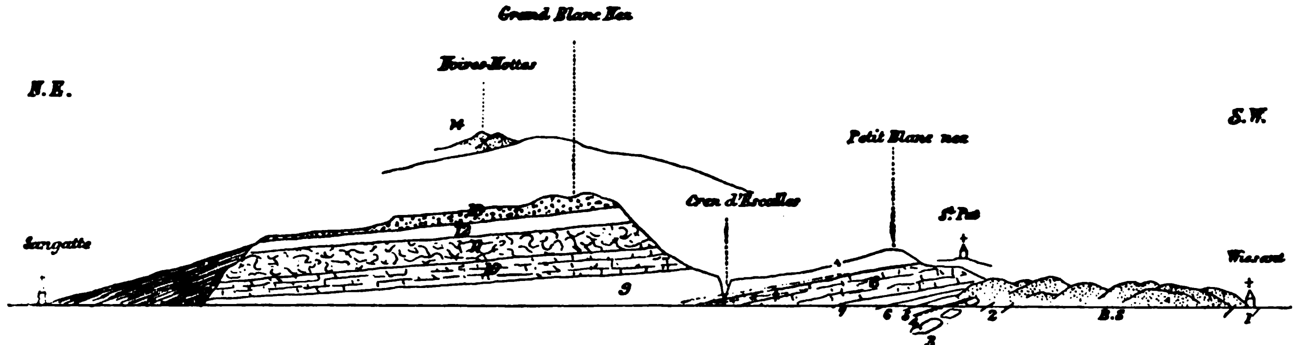
28 P⁴. Is the bed in which Fitton pointed out the *Cypris* of the Purbeck, which is very poorly represented in Boulonnais.

In 29, (Hastings Sands,) I have recently discovered Wealden fossils—*Cyrena* and *Unio*.

§ 6. Cretaceous.

The Chalk hills forming the Upper Boulonnais, bordering escarpment of Lower Boulonnais, are very well exposed in the Blanc-nez cliffs. The following section is the result of the geological observations of Phillips, Fitton, Topley, Gaudry, Chellonneix, Potier, de Lapparent, and myself:—

FIG. 6.—SECTION OF BLANC-NEZ.



Length about six miles.

The Blanc-Nez chalky cliffs can be divided into several Palæontological zones in the following ascending order :—

1. Ferruginous sand (Wealden).
2. Black Clay with Ostrea sinuata (Sandgate beds).
3. Green sandstones and sands (Folkestone beds).
4. Bed of Phosphatic nodules with Ammonites mammillaris.
5. Deep blue clay with Ammonites interruptus.
6. Grey marly clay with Ammonites inflatus.
7. Chloritic marl with Ammonites laticlavius.
8. Marl with Ammonites varians, and bed with Plocoscyphia meandrina at the base.
9. Marl with Ammonites Rotomagensis.
10. Marl with Belemnites plenus.
11. Nodular hard chalk with Inoceramus labiatus.
12. White chalk with Terebratulina gracilis.
13. Flinty chalk with micraster breviporus.
14. Outlier of Iron sand (Crag ?)
15. Post-Tertiary beds of Sangatte.

	FT.	IN.
1. *Ferruginous Sand.*—This sand is exposed at Wissant; it is best developed towards the south and south-east of Lower Boulonnais, where it forms a range of hills running more or less parallel with the Chalk. The hills of the central district are often capped by these ferruginous sands; some very interesting sections are exposed near Equihen and St. Etienne-au-Mont, where several pits show irregularly alternating beds of ferruginous sands, pebbles, and mottled clays. This series of ferruginous sands is Wealden; MM. Rigaux and Pellat have found in it *Unio*, *Cyclas*, and *Cyrena*. On the English coast the great division between Hastings Sands and Weald Clay is very marked, as also are the subordinate divisions of the Hastings Sands; but it is impossible to say, according to Topley, what part of the English series the Boulonnais beds represent................	100	0
2. *Dark clay with Ostrea sinuata and Ostrea cf. Leymeriei.*—This clay, with large oysters, was discovered by M. Gaudry. I think it an equivalent of the Sandgate beds.		
3. *Coarse Calcareous Sandstone with green grains.*—Masses of sandstone are seen at Wissant below the Gault; they correspond exactly to the upper part of the Folkestone Beds at Copt Point. This coarse, hard, calcareous sandstone stands out in rocks at low-water at Wissant; it passes in some parts into green sands of varying thickness....................	12	8
4. *Phosphatic Nodules with Am. mamillaris.*—These phosphatic nodules and casts of *Am. mamillaris*, *Am. Beudanti*, and *Inoc. Salomoni* form a thin bed in loose quartzose sands with green grains, sometimes indurated in sandstone. There is no definite line of separation between this bed and the underlying one: this is the *Am. mammillaris* zone of the Gault	2	0
5. *Dark Blue Clay with Am. interruptus* (*Am. interruptus* zone of the Gault).—This is the true typical Gault. The palæontological zones so well worked		

FT. IN.

at Folkestone by Mr. F. G. H. Price have not yet been recognised at Wissant; the Gault is much thinner in the Boulonnais than in Kent, but has generally the same characters in both places. This division of the Wissant cliffs corresponds to the division I. to VIII. of Mr. Price's papers. A layer of phosphatic and pyritous nodules about one foot thick has been worked at the base of this bed in the Boulonnais; it is seen at the same place in the south-east of England. I have given a full list of the fossils of this division in the "Annales of the Geological Society of Lille" (Vol. v.)........ ...... 16 8

6. *Grey Marly Clay with Ammonites inflatus, Inoceramus sulcatus, Pecten Raulinianus, Nucula bivirgata,* &c. —This division corresponds to the Nos. VIII. to XI. of Mr. Price; it has long been considered as Gault. I pointed out its fauna to be of Upper Greensand age, and showed that this clay should be correlated with parts of the arenaceous beds of Southern England and Eastern France described as Upper Greensand. The able papers of Mr. Jukes-Browne and of several other observers fully agree with me on this point 23 4

7. *Chloritic Marl with Am. laticlavius.*—I agree with MM. Jukes-Browne, Meÿer, and Price, in considering this glauconitic bed as the true Chloritic Marl; it must not be correlated with the English Upper Greensand, as said by Fitton and by all geologists after him. The lower part of this bed is a green-sand with phosphatic nodules passing into very green, clayey sand (4 feet); the upper part is Chalk Marl with green grains, sandy, and containing still some nodules (5 feet). Some fossils of this bed are derived, but the greater part, and it is very fossiliferous, belongs to it, as stated in my last list ("Annales of Société Géologique du Nord," Vol. v.). 10 0

8. *Bed of Ammonites varians.*—Chalk Marl, sandy at the base, clayey at the top; the basement bed is

FT. IN.

nodular, and full of *Plocoscyphia meandrina*, and *Dendrospongia fenestralis*. The following fossils are common in this division: *Ammonites varians*, *Am. Rotomagensis*, *Am. Mantelli*, *Am. falcatus*, *Turrulites Scheuchzerianus*, *T. tuberculatus*, *T. costatus*, *Nautilus Deslongchampsianus*, *Terebratula semiglobosa*, *Kingena lima*, *Rhynchonella Martini*, *Pecten laminosus*, *Inoceramus orbicularis*, *Holaster subglobosus*, and *H. Trecensis*. Mr. F. G. H. Price has recently traced much more accurate palæontological divisions than those in the opposite English cliffs 50 0

9. *Bed of Ammonites Rotomagensis*.—Compact grey marly chalk with *Am. varians*, *Am. Rotomagensis*, *Am. Austeni*, *Ostrea vesicularis*, *Plicatula inflata*, *Pecten laminosus*, *Inoceramus virgatus*, *Rhynchonella Mantellana*, *Vermicularia umbonata*, and *Holaster subglobosus*. This bed forms with the underlying one the *Zone of Holaster subglobosus*. I gathered in the same zone in the Folkestone cliffs several sea-urchins, and have sent them, since the publication of my last papers on the English Chalk, to M. Cotteau, who has identified the following species; their names are not without interest to the English geologists: *Cidaris vesiculosa*, Gold., *Pseudodiadema variolare*, Desor, *Pseudodiadema Michelini*, Desor, *Pseudodiadema ornatum*, Desor, *Pseudodiadema pseudoornatum*, Cotteau, *Echinocyphus difficilis*, Forbes, *Peltastes clathratus*, Cotteau, *Hemiaster Morrisii*, Forbes, and *Hemiaster Griepenkerli*, Strombeck 66 0

10. *Zone of Belemnites plenus*.—Hard whitish chalk marl, becoming greyish higher up; at the top is a pale green marly bed 2 feet thick, where Dr. Robbe of Sangatte, and M. Chellonneix have found many *Belemnites plenus*. In the underlying marls are found *Belemnites plenus* (very rare), *Cerithium Luschitzianum*, *Solarium Gosseleti*, *Pecten membranaceus*, *P. laminosus*, *Janira costata*, *Plicatula*

	FT.	IN.
nodosa, Inoceramus virgatus, Ostrea Lesueurii, O. haliotoïdea, O. Naumanni, O. lateralis, Magas Geinitzii, Terebratula semiglobosa, T. squammosa, Kingena lima, Terebratulina striata, T. rigida, Rhynchonella grasiana, Rh. Martini, Rh. Mantellana, Terebratella cf. Menardi, Serpula amphisbena, Vermicularia umbonata, Serpula subrugosa, Hemiaster bufo, Micrabacia coronula, Onchotrochus serpentinus, &c.	66	0
11. *Concretionary Nodular Chalk with Inoceramus labiatus.*—This division is the basement bed of d'Orbigny's Turonian stage; it is a very hard gritty chalk, greenish or yellowish, chiefly made up of fragments of Inocerami and other fossils: *Ammonites nodosoïdes, A. rusticus, A. peramplus, A. Lewesiensis, Inoceramus labiatus, Rhynchonella Cuvieri, Terebratula semiglobosa, Discoïdea minima, Cidaris hirudo, Cyphosoma radiatum, Cyphosoma spatuliferum* (?) Forbes, and *Cardiaster pygmæus*...	66	0
12. *Compact White Chalk with Terebratulina gracilis.*—Very compact, marly, and thick-bedded chalk, containing some flints in its higher part: *Ptychodus mammillaris, Beryx* sp., *Inoceramus Brougniarti, In. labiatus, Spondylus spinosus, Terebratulina gracilis, Terebratula semiglobosa, Echinoconus subrotundus*, and *Holaster coravium*	120	0
13. *Hard White Chalk with Flints* (assise of *Micraster breviporus*), forming the top of the Blanc-nez cliff: *Inoceramus undulatus, I. inæquivalvis, Ostrea sulcata, Spondylus spinosus, Terebratula semiglobosa, Rhynchonella plicatilis, Holaster planus, Micraster breviporus, Echinocorys gibbus*, and *Cylindrospongia coalescens.*		
14. *Hard Sandy Chalk* (zone of *Micraster cortestudinarium*).—This zone, together with the preceding one, is not here more than 50 feet; it is seen in the downs over the Blanc-nez cliff, and at Setques, where it is quarried as a building stone: *Pecten Dujardini, Rhynchonella plicatilis, Tere-*		

bratula Hibernica, *Ostrea hippopodium*, *Micraster breviporus*, and *M. cortestudinarium*.

15. *White Chalk with Flints* (zone of *Inoceramus involutus*) is seen at the top of the Blanc-nez downs, and in the ancient pits north of Peuplingue: *Inoceramus involutus*, *I. Mantelli*, *Echinoconus conicus*, and *Echinocorys gibbus*.

16. *White Soft Chalk with Flints* (zone of *Marsupites*). —This division is the upper one actually recorded in the Chalk of Boulonnais; it is well exposed in the neighbourhood of St. Omer, as at Wisques, St. Martin-au-Laërt, &c.: *Belemnitella vera*, *Pecten cretosus*, *Plicatula sigillina*, *Terebratula semiglobosa*, *Rhynchonella plicatilis*, *Thecidea Wetherelli*, *Echinoconus conicus*, *Cidaris sceptrifera*, *Cidaris clavigera*, *Micraster coranguinum*, and *Echinocorys gibbus*. This is the Margate Chalk.

§ 7. Post-Tertiary Deposits.

In Boulonnais, after the Cretaceous, we come to a great gap in the series of geological formations, the thick mass of the Tertiary beds being unrepresented, with the exception of small Woolwich and Reading Sands outliers on the Chalk of southern Boulonnais, and other Crag Outliers at the Moires-mottes capping the Blanc-nez downs. Generally, we pass directly in the district from the older formations to the far newer set of deposits now usually massed under the term Drift.

In the following lines the various drifts will be shortly described in what seems most likely to be their natural order, beginning with the oldest; but it must not be forgotten, we have no superposition to depend on in classifying the various drifts, and their succession and relative position cannot be yet considered as absolutely established in Northern France. These divisions generally agree with those described in the London basin by Mr. Whitaker and other Survey geologists.

1. *Plateau Gravel.*—Certain gravel-patches occur at high levels, capping some of the Chalk downs, and without any connection with the present valley-system. Such are those of

Camp d'Helfaut, Forest of Ruminghem, at about 130 feet the present sea level; possibly some of them may turn out t of the same age as the undermentioned bed A of the San Drift cliff section.

2. *Clay with Flints.*—The Upper Boulonnais Chalk tra covered by a stiff brown clay with unworn flints. This lies ver regularly on the Chalk, nearly everywhere indeed in "pipes." I the unworn character of the contained flints we may infer tha deposit has been formed on the spot where it is now found, partly by the dissolving away of the chalk of which the give evidence. Much discussion has lately been held on clays with flints both in England and France; in Pas-de-C and Somme, they are named *Bief à silex*, and considered as by M. de Mercey and others; in Nord and Aisne, there are b clays with flints, lithologically identical to these, and whicl covered by the Sands of the Woolwich and Reading series.

3. *Brickearth.*—The clay with flints is in great part covere a more important bed, a light brown ferruginous clayey sand loamy nature, which is often worked for bricks. This *Brick Loess, Limon des plateaux* of the French, *Limon Hesbayen* o Belgians, extends beyond the Upper Boulonnais Chalk tra may be seen also in Lower Boulonnais at Le Wast, I Ferques, &c. The origin of this brickearth is rather doubtfu sometimes it seems to be a mixture of re-assorted underlying l it is of fluviatile origin for some geologists, and of glacial c for other geologists, amongst which is M. de Mercey.

Before describing the River-Drifts of the region, I must the important section of the Sangatte cliff, already illustrat Prof. Prestwich, E. Sauvage, Hamy, and Chellonneix. The cession of the beds is the following, in ascending order :—

A. 4 *to* 8 *feet.*—Black Chalk flints, mostly rather large, a a good deal rolled and worn, with a few rolled blocks of fallen from the old cliff, and with some pieces of Tertiary sandstone. This is a raised beach, rising about 17 feet abov present sea level. Above the shingle are some light col sands, with seams of greensand and subordinate beds of sh amongst which Prof. Prestwich discovered fragments of ch Lower Greensand origin, pebbles of Lydian stone derived fro Portland Beds, pebbles of sandstone from Lower Boulonnais

two pebbles of a red granite. I think this raised beach to be in relation with those I lately described in Brittany; they give evidence of icy conditions in this region in the early times of the drifts; ground-ice was then forming in the rivers of the English Channel basin, this ice was afterwards floated, carried into the English Channel then extending over the adjoining low-lands, and dropped over them their loads of earth and stones.

B. 50 *to* 80 *feet.*—Chalk rubble and angular flint gravel with sand and clay, of a dirty cream or greenish colour, with imbedded fragments and masses of chalk, and here and there a large unrolled flint. This is the *Diluvium gris* of MM. Sauvage and Hamy. The whole is roughly bedded; irregular seams of fine chalk rubble and marl are intercalated with the flint *débris*; there are in addition some beds which are not to be distinguished from ordinary Loess. They not only resemble that deposit in general characters, but contain several species of land-shells common in the Loess; such are the following ones found by Prof. Prestwich, and identified by Mr. Gwyn-Jeffreys:—*Helix concinna*, *H. pulchella*, *Succinea oblonga*, *Pupa marginata*, *Arion ater*, and *Limax agrestis*. At the top of this series Dr. Robbe of Sangatte has found the inferior jaw of an *Elephas primigenius* and the humerus of another mammal in the sandy loess with chalk rubble; he discovered also shells of *Unios* in one of the sandy beds at the base of the series.

C. 10 *to* 20 *feet.*—Mass of angular flint gravel, principally composed of broken Chalk flints, but containing also a considerable quantity of angular flat lumps of a coarse iron sandstone. This mass is separated from the underlying bed by an irregular but well defined line; it forms the *Diluvium rouge* of MM. Sauvage and Hamy.

River Deposits.

4. *River Drifts.*—The River drifts in Upper Boulonnais are loamy near Nielles-les-Calais, Guines, &c; they are made of subangular flints at Ouve, Blandecques, and Vaudricourt, where they have yielded bones of great extinct Mammalia with Palœolithic flint implements. In Lower Boulonnais the River-drifts are gravelly, and contain rounded pebbles of the different rocks of the district; they are well exposed near Wimereux and on the Gris-nez promontory.

5. *Modern River Deposits.*—These newest deposits have but very

little importance in Boulonnais; they are, on the other hand, of gr importance in the adjoining French Flanders, where the pap of Mr. Debray have shown the considerable changes in the ri beds, and of the coast line since the Historical Period.

Before concluding this brief review of the Post-Terti deposits of Boulonnais, it must be noted that blown-sand actually accumulating and forming dunes on the low shores Boulonnais exposed to the S.W. winds.

It will be also interesting to add that Neolithic stone im ments have been found in the district, and described by M Sauvage and Hamy, Lejeune, and others.

§ 8. Disturbances of the Strata in Connection with Formation of the Hercynian Mountain System.

The Palæozoic beds of Boulonnais are the continuation, previously stated, of those of the Mendip and of the Arden hills; this tract of land is continuous farther east as far as Pola and was first named by d'Omalius d'Halloy the *Hercyn Mountain range.*

The formation of this mountain range is related to the turbances of its strata. When the deposition of the Lo Silurian (Faune seconde) was ended, the movement called by P Gosselet "Folding of Ardennes" took place. Its effect was uplift the existing sediments of Ardennes, Brabant, &c., and cause them to dip to the south; the beds which originally dip north were completely reversed. We must consequently consi this *folding of Ardennes* as caused by a considerable thrust from south to north, as if the Ardennes Table-land had b pushed towards the Brabant Table-land. It is doubtless at same period, and connected with this Hercynian line of weakn that the volcanic outbursts, whose products have been fully stuc by MM. de la Valleé-Poussin and Renard,* acquired their grea activity.

This *folding of Ardennes* was the initial cause of the Din and Namur basins; it was followed by a long continued depress of the area, in consequence of which the accumulation of enormous thickness of stratified rocks within the great troughs

* De a Valleé-Poussin and Renard: "Mémoir. cour. Académie Belgique," 1876.

Dinant and of Namur took place, and this was the preliminary stage of the formation of the Hercynian Mountain system.

The geosynclinal of the Hercynian appears to have been forming during the whole interval between the Silurian and the Oligocene, and perhaps unto the present day. During so long a period this downward bending of the crust did not go on indefinitely; after the period of the Mountain Limestone, littoral, brackish water, and finally lacustrine and terrestrial deposits came in, and the coal continued forming. Thus it is clear that the lateral thrust to which the thickened masses of sediments of the Hercynian line of weakness had been so long subjected, as the Appalachian, according to Prof. Hall,* and as the Alpine lines, according to Prof. Judd,† resulted at the close of the Coal Measures in a general elevatory movement, succeeding the subsidences of the Devonico-carboniferous periods, and the oscillatory effects of the Coal Measures.

A general elevatory movement, which took place towards the end of the Coal Measures, was named by Prof. Gosselet the "Folding of Hainaut;" it appears to have taken place suddenly, and as if it had been determined by a crushing from the south to the north: this thrust had a more violent effect in the Namur than in the Dinant basin, the beds in this Namur basin being often turned upside down. The upheaval of the beds caused by this *Folding of Hainaut* was a considerable one, and the Hercynian Mountain range became then at least equal in elevation to our modern Alps, as fully proved by Cornet and Briart‡ in their plates so accurately drawn to scale.

These masses so elevated into high regions of the atmosphere were subjected to the destructive effects of moisture, frost, and heat, and to the transporting powers of water and ice during very long periods, from the Coal Measures to the Oolitic in Boulonnais and to the Cretaceous in the Ardennes. These denuding forces acting on the Hercynian mountains during so long a time had reduced the high Post-Palæozoic mountains to low hills at the close of the Secondary period; and we must consider the Aache-

* Prof. Hall, "Paleontology of New York," Vol. 3; see also, Dana: "Silliman's Journal."

† J. Judd: On Volcanoes ("Geological Magazine").

‡ Cornet and Briart: de Relief du sol en Belgique après les temps Paléozoïques ("Mém. Soc. Geolog. de Belgique," Vol. iv., p. 74, 1877).

nian formation* as the result of these during long atmosphe denudations, rather than as a formation correlative with special part of the Cretaceous series.

A great part of the Hercynian hilly region was submerged the time of the chalky deposits of the Anglo-French Cretace ocean. This Chalk still covers the districts situated between Mendip Hills and the Boulonnais, and thence to the Ardennes; extended once much farther, as Cretaceous flints have been fou scattered on this Palæozoic table-land.

I have paid some special attention to the Cretaceous series this province, and one of the results of my studies, a pointed out‡ in 1875, was to show that an important elevat movement took place in this region during the Oligocene, wh affected the Cretaceous beds. I established as a general fact t the foldings of the Cretaceous beds of the south-eastern part England and of the north-eastern part of France presented b an equally high dip to the north, and a very low dip to the sou It seems as if the beds had been thrust from south to nor an exaggeration of this thrust would have resulted, as in Palæozoic underlying series, in a general dip of the beds to south, the beds lying south of the synclinal lines would have b reversed on those situated north of it. This reversion of the b has even happened accidentally in some points of the crest of Chalk downs of Purbeck; there the beds are regularly inclinec the north, as in the Isle of Wight crest, but sometimes northern dip exceeds 90° and then becomes south, as is the cas Man-of-War cove=70° S., and at Durdle cove=80° S.

It is thus seen that the Oligocene movement of the Hercyr area, as read in the Cretaceous disturbed rocks of the region, an horizontal thrust from south to north. Let us, by analc name this movement the "Folding of the Downs;" and t remember the different upheavals of the country situated betw the Mendips and the Ardennes.

* Cornet and Briart: Description de l'étage Inférieur du T. Crétacé Hainaut ("Mém. Cour. Acad. de Belgique," vol. 33). Ch. Barrois: l'Aachénien ("Bull. Soc. Géol. de France," Vol. 3, p. 257).

† Dumont: Mém. sur le T. Crétacé de la Belgique. Bruxelles, 1878,

‡ Ch. Barrois: Ondulations de la craie dans le Sud de l'Anglet ("Annal. Soc. Géol. de Lille," Vol. ii., p. 85, March, 1877).

Ch. Barrois: Recherches sur le T. Crétacé Sup. de l'Angleterre e l'Irlande ("Lille," 1876, p. 118, and plate 3, fig. 8).

1. *Folding of Ardennes*............ *Lower Silurian.*
2. *Folding of Hainaut* .... *Coal Measures.*
3. *Folding of the Downs* .... *Oligocene.*

The comparative study of these foldings afford us evidence that the Hercynian Mountain-system was formed at three different very remote periods, and that the three elevatory movements were identically horizontal thrusts acting from south to north.

This similarity of movements during long geological periods is far from being special to the Hercynian region; it has been given as explanatory of the formation of the Alps by E. Suess,* and of the Erzgebirge by Prof. H. Credner†; it can, however, be stated that I had arrived independently (l.c., March, 1875) at the same result for the English Channel region.

The Hercynian system or mountain range is not formed by an upheaval caused by a force acting from within the earth vertically upwards; the disturbing force was of the nature of a *horizontal thrust.* This lateral pression is a surface phenomenon caused by the contraction of the solid crust of the earth, and so we have here a material illustration of the views of Descartes (1668) and Constant Prévost (1840), according to which the displacement of the rocks and the elevations of the surface were caused by the earth's contraction.

This Hercynian Mountain range is the effect of horizontal displacement of the Hercynian area in the same directions at different periods. These far remote geological periods at which this district has been subjected to similar movements (*Folding of Ardennes, Folding of Hainaut, Folding of the Downs*) seem to have been marked in the neighbouring portions of northern Europe, which have been best studied by geologists, by the most violent outbursts of volcanic forces; while in the intermediate periods, as stated by Prof. Judd, few, if any, traces of such action can be discovered.

* E. Suess: "Die Entshehung der Alpen." Wien, 1877.

† Hermann Credner: "Das Vogtländish-Erzgebirgische Erdbeben von Nov., 1875" ("Zeits. f. d. gesammt. Naturw.," Bd. xlviii., p. 246, 1876).

EXCURSION TO THE GORGE OF THE MOLE, BOX HILL, AND DORKING.

SATURDAY, JULY 13TH, 1878.

Director :—J. LOGAN LOBLEY, F.G.S.

On leaving the train at Leatherhead the party speedily entered the mouth of the valley or gorge, which traverses the North Downs from Leatherhead to Box Hill, and through which the river Mole makes its way on its northern course to the Thames. The northern end of the valley is comparatively open, the bounding hills being of low elevation; but in a little time the gorge becomes more decided, the hills at either side increasing in boldness until the southern end is reached, where Box Hill attains an elevation of about eight hundred feet. The length of the valley, following its windings, is about five miles, the North Downs being here about four miles in width. This is one of four transverse valleys by which four rivers, draining a large portion of the Wealden area, cross the North Downs. These are, from west to east, the Wey, the Mole, the Darent and the Medway.

Proceeding along the eastern side of the river, Norham Park is reached. Through this beautiful park the Mole runs for some distance, and in several places along this part of its course some of the water finds an underground passage, by what are locally called "Swallow Holes," when the river rises to a certain height.

After passing through the village of Mickleham, Juniper Hill was ascended, and very striking and beautiful views of the valley were obtained from this hill, so well known from the fact that it is clothed with Juniper trees of great size and beauty. The neighbouring Box Hill, at the southern extremity of the gorge, was soon afterwards reached and ascended. The great difference in the vegetation of the two hills is very striking, for while it is difficult to find a Box tree on Juniper Hill, it is difficult to find a Juniper on Box Hill which is densely covered with the trees which give to this well-known hill its name. One side of Box Hill forms a part of the escarpment of the North Downs, which is here very steep. Rapidly descending the escarpment, the Upper Greensand was crossed at the bottom of the declivity, and the narrow outcrop of

the Gault was passed over, when sections of the Lower Greensand near the mill and railway cutting, near Dorking, were pointed out, by the Director, who then led the party to the Dorking Station for the return journey to London.

EXCURSION TO BOULONNAIS.

MONDAY, AUGUST 5TH, 1878, AND FIVE FOLLOWING DAYS.

Directors—EDM. PELLAT, Dr. CH. BARROIS, Prof. GOSSELET, M. RIGAUX, Dr. SAUVAGE, and S. R. PATTISON, F.G.S.

(*Report by* DR. BARROIS.)

Leaving London by the tidal train, the Members of the Association arrived at Boulogne at 3.40 p.m., and were there joined by the Directors and by several Members of the Société Académique de Boulogne, and of the Société Géologique du Nord. They at once proceeded through the town, to the Etablissement Municipal des Bains, where M. A. Huguet (the Mayor of Boulogne) gave a welcome to the Geologists' Association, and invited the Members to a lunch. Mr. S. R. Pattison, director of the party, thanked the Mayor of Boulogne.

After a short stay at the Etablissement Municipal des Bains, the party drove to Wimereux, and then came back to Boulogne along the shore, seeing the fine section of the Portlandian and Kimmeridgian cliffs. Several French geologists joined the party, amongst whom were M.M. Lejeune, Curator of the Museum of Calais; Lemesle, C.E., Lodin, M.E., Dr. Robbe, of Sangatte, and the following Members of the Société Géologique du Nord:—M.M. D'Ault Dumesnil, Jules Barrois, Billet, R. Crespel, Emile Dutertre, Giard, Gosselet, Lecocq, Lisbet, Potier, and Six.

The following beds were observed in the cliffs south of Wimereux:—

W.	Sands and ferruginous sandstones, with *Unio* (Wealden).	
P.	P^4 Travertine, Cypris bed of Dr. Fitton (Purbeck).	
	P^3 Siliceous limestone, with *Cardium dissimile*	Portland Stone.
	P^2 Sands and Sandstones, with *Natica ceres*, and *Trigonia gibbosa*	Portland Stone.
	P^1 Sands and Sandstones, with *Trigonia radiata* and *Serpula coacervata*...	Portland Stone.

O.	O^2 Glauconitic clays, with *Ostrea expansa* ...	Portland Sa
	O^1 Clays with *Cardium Morinicum*	Hartwell.
N.	N^4 Sandstone with *Pterocera oceani*	French Portlandian
	N^3 Sands with *Pernæ*	
	N^2 Conglomerate with *Trigonia Pellati*	
	N^1 Sandstone with *Ammonites Portlandicus* (*gigas*)... ...	
M^2	Superior shales and limestones of Chatillon	
M^1	Inferior shales and limestone of Chatillon, with *Ammonites pseudomutabilis*	Virgulian.
L.	Sands and Sandstones of Moulin Hubert	
K.	Superior clays and limestones of Moulin Hubert cliff, with *Ammonites caletanus*	
J.	Sands and Sandstones of Conninothun	Ptero-cerian.
I.	Inferior clays and limestones of the Moulin Hubert cliff, with *Ammonites orthoceras*	

The beds are described in the paper of M. Pellat, printed in our "Proceedings." Mr. Hudleston pointed out that the Boulonnais Upper Portlandian reminded him more of the appearance of the Purbeckian and Portlandian, as seen at Swindon, than of the Portlandian limestones of Weymouth. An ammonite similar to the *A. portlandicus* of P^1 is found in England, both in the Portland Stone, and in the Portland Sand.

Mr. Dowker pointed out the interesting fact that the rock with *Astarte socialis* had been used in the Roman buildings of Kent.

Prof. Giard, of the University of Lille, called the attention of the party to the fact that the beds bored by recent *Tapes* are found on the shore, at a higher level than that at present habited by those animals.

The party returned to Boulogne, Hotel du Louvre, for the night. There, were received cards from the Corporation of Boulogne, inviting the Members of the Association to the Etablissement Municipal des Bains (manager, J. Spiers, C.E.) during their stay in Boulogne.

Tuesday.—The Members left Boulogne in carriages at 8 a.m., and drove to Mount Lambert, where the section from O. to I. was seen; the party then proceeded to Echinghen to see the lower beds, from I. to E. of the section. The Members of the Association then left Echinghen, and directed by MM. Pellat, Rigaux, and Sauvage proceeded to Belle, Mount des Boucards, Le Wast, and les Pichottes, where the following beds were successively seen :—

H. Thirteen beds and small beds of Brequerecque, with *Pholadomya hortulana*.

G. Sandstone of Wirvigne, with *Pygurus Jurensis*.

F3 Marls, oolites, and sandy limestone of Bellebrune.

F2 Clays with *Ostrea deltoïdea* and compact limestones with *Lithodomi*.

F1 Pisolitic limestone with large *Nerineæ* of Hesdin l'Abbé.

E. Siliceous limestones of Echinghen with *Astarte Morini* and *Trigonia Broonni*.

D. Clays of Brucdale with *Ostrea deltoïdea*, of which the clays with deltoïdean *Ostreæ* of the Mount of Boucards appear to be the equivalent.

A. Coralline Limestone of Brucdale. The Coralline Limestone of the Liane Valley and some limestones below it have probably their equivalents in the north and east of the Boulonnais in the limestones of the Mount des Boucards.

6. Limestones of Houllefort with *Opis* and *Pseudomelania Heddingtonensis*.

Upper beds of the Liégette with *Am. Martelli* and sponges.

5. Clays and limestones with *Terebratula impressa* and *Millericrinus* in the middle beds of the Liégette.

4. Black clays of the north of Le Wast, with small pyritous Ammonites—*A. Rengeri*, &c.

3. Marly splittery limestones of the south of Le Wast, with *Am. Lamberti*.

2. Clays and sandy limestones, south of Le Wast, with *Serpula vertebralis* and *Ammonites Duncani*.

1. Ferruginous clays of Belle and Alincthun, with *Ammonites Calloriensis*.

Cornbrash, at Pichottes.

Mr. Hudleston is of opinion that the Oolite F^1 is probably of the age of the higher Corallian beds of the Weymouth district; the sandstone of Wirvigne (G) may be classed as a sort of Upper Calcareous Grit. The limestone of Houllefort should be correlated with the Coralline Oolite, or possibly with shelly Passage-beds at the top of the Lower Calcareous Grit.

The party started late from the Cornbrash pits of Pichottes, and arrived at Boulogne at night.

WEDNESDAY.—The Members started this day by the 7 a.m.

train for Marquise. The following is the sequence of the Lower Oolites as shown to the party by Dr. Sauvage and Rigaux in the Rinxent railway cuttings, and in several pits around Marquise:—

D. Siliceous and oolitic limestone of Belle and Bellebrune, with *Rhynchonella Badensis*, identical with the English Cornbrash.

C. Marly limestone, burnt for lime, with *Rhynchonella elegantula*, equivalent to the *Forest marble;* numerous *Acrosalenia Lamarckii.*

B. Marquise oolitic limestone, with *Rhynchonella Hopkinsii*, considered as representative of the siliceous limestone of Minchinhampton.

A. Hydrequent limestone (Fuller's Earth), with *Ostrea Sowerbyi* and *Modiolæ* in the lower part, and Gasteropods and Brachiopods in the upper part; it rests on pyritous and lignitous sands.

After a merry breakfast at Marquise, the party proceeded to Hydrequent pits, where Professor Gosselet took the direction of the Excursion. There the marly limestones of the Fuller's Earth, with *Ostrea Sowerbyi*, rests on the denuded surface of the Carboniferous Limestone.

In following the Haut-banc Valley are seen good sections of the Mountain Limestone series in the following order:—

Shales (Coal Measures).
Sandstone of the Plaines (Millstone Grit).
Limestone, with *Productus giganteus.*
Napoleon Limestone, with *Productus undatus.*
Limestone of the Haut-Banc, with *Productus cora.*
Dolomite of le Hure.

The Members of the Association did not succeed in finding any fossil plants in the Coal Measure shales of the Hardinghen mine, but they were fortunate enough to find in them several brackish water shells of the genera *Anthracomya* and *Anthracosya*, totally unknown before in the Coal Measures of Boulonnais.

At Hardinghen the Palæozoic rocks are covered by the *Am. mammillaris* zone of the Gault, worked for the phosphatic nodules it contains. From Hardinghen the party went back to the

Rinxent Railway station, and then by train to Boulogne. The evening was spent in the Casino, where the Members of the Association had been invited to a great concert of music by the Mayor and Corporation of Boulogne.

THURSDAY.—We left Boulogne, as on the preceding day, by the 7 a.m. train to Marquise; there, after breakfast, we began, with Professor Gosselet and several members of the Société Géologique du Nord, who had joined us, a complete section of the Palæozoic rocks of Boulonnais, from Blecquenecques to Caffiers.

North of Blecquenecques are several pits, where are quarried a tough violet-bluish limestone, with *Productus cora* and *Lithostrotion*, covered by a whitish compact limestone, with *Spirifer glaber*, *Productus undatus* (Napoleon marble). These limestones are broken by a fault. The Coal Measures are worked north of the fault, and the seams pass below the Carboniferous Limestone (Napoleon Marble) seen before; further north, below the Coal Measures, is found the regular series of the Palæozoic beds. The series of the beds is the following in descending order :—

11b. Coal Measures of Locquinghen, with *Pecopteris Loshii*, *Sphenopteris coralloïdes*, *Sphenophyllum erosum*, *Annularia radiata*, *Calamites Suckowii*, &c.

11a. The Plaines of Hardinghen sandstone (Millstone Grit), with *Productus Flemingii*.

10. Limestone with *Productus giganteus*.

9. Napoleon Marble, with *Productus undatus* and *Spirifer glaber*.

8. Haut-banc Limestone, with *Productus cora*.

7. Dolomite of le Hure Mill, with crinoidal remains.

6. Fiennes Sandstone, with *Cucullæa Hardingii* and *C. Trapezium*. Below are found the red shales, that we consider of the same age as those met with in the deep well of the Meux brewery, London.

5. Ferques limestone, with *Spirifer Verneuili*, *S. Bouchardi*, *Atrypa reticularis*, *Rhynch, Boloniensis*, *Cyathophyllum hexagonum*, and *Favosites Boloniense*.

3, 4. Shales of Beaulieu, with *Spirifer Verneuili*, *S. Sauvagei*, *S. Barroisi*, *Strophomena Gosseleti*, and *Cyrtina heteroclita*. In the middle of this formation is the Dolomite of les Noces.

2. Blacourt Limestone, with *Orthis striatula*, *Cyrtina heteroclita*, and *Productus subaculeatus*.

1. Conglomerates, red shales, and green sandstones of Blacourt—ferns, calamites.
   S. Silurian.

Mr. J. Grant a Member of the Association, found a very interesting fossil in the Blacourt Limestone—*Spirifer Orbelianus* (Abich)—as that form was only hitherto known in Ardennes and in Russia.

Mr. Rigaux called attention to the subdivisions of the Beaulieu Shales, where he has traced the following palæontological zones:—

Limestone with *Pentamerus brevirostris*.
Marl with *Streptorhynchus elegans*.
Clay with *Streptorhynchus Bouchardi*.
Shales with *Spirigera Davidsoni*.

Professor Gosselet spoke on the Geological History of the Palæozoic Rocks of Boulonnais, and of their relation with the formation of the Ardennes and of the Mendip Hills.

Dr. Barrois noticed the connection between the disturbances of these strata and the formation of the Hercynian Mountain system by lateral pressure.

The party then proceeded to Caffiers, and then by train to Boulogne. In the evening they went, at half-past nine, to the Folkestone Hotel, where they had been invited to a tea-lunch by the Société Académique and the Société Médicale of Boulogne. The meeting was a pleasant one, and several speeches were made by MM. Guerlain, President of the Medical Society; Platrier, President of the Academical Society; Pattison, Foulerton, Parker, Pellat, Gosselet, A. Huguet (Mayor of Boulogne), Najean (Sous Préfet of Boulogne).

Friday.—Leaving Boulogne by the 7 a.m. train, the Members of the Association arrived at Calais, where they were waited for by M. Lejeune, one of the Curators of the Calais Museum. The Members first visited the collections of the Museum, and were specially interested with the remarkable series of flint implements, found in the neighbourhood and in Boulonnais by M. Lejeune.

After breakfast they drove to Sangatte, where the interesting

cores found in the dredgings in the Channel, and the other preparatory work for the tunnel between England and France, were exhibited by M. Potier, chief engineer in care of the scientific part of the work. They then also visited the good collection of Cretaceous and Post-Tertiary fossils found in the neighbouring cliffs by Dr. Robbe.

The party then left Sangatte, with M. Potier and Dr. Robbe, who acted as Directors at the Cretaceous cliffs during the whole day. They walked along the beach to Wissant, seeing on their way in the Blanc-nez chalky cliffs the following palæontological zones in descending order :—

15. Post-Tertiary beds of Sangatte.
14. Outlier of iron-sand (Crag ?)
13. Flinty Chalk with *Micraster breviporus.*
12. White Chalk with *Terebratulina gracilis.*
11. Nodular hard Chalk with *Inoceramus labiatus.*
10. Marl with *Belemnites plenus.*
9. Marl with *Ammonites Rotomagensis.*
8. Marl with *Ammonites varians*, and bed with *Plocoscyphia meandrina* at the base.
7. Chloritic Marl with *Ammonites laticlavius.*
6. Grey Marl with *Ammonites inflatus.*
5. Deep blue Clay with *Ammonites interruptus.*
4. Bed of Phosphatic Nodules with *Ammonites mamillaris.*
3. Green Sandstone and Sands (Folkestone Beds).
2. Black Clay with *Ostrea sinuata* (Sandgate Beds).
1. Ferruginous Sand (Wealden).

Arrived at Wissant, some of the party returned to Calais, with MM. Lejeune, Potier, and Robbe, to whom Dr. Foulerton proposed a vote of thanks, which was carried by acclamation. The mass of the party then drove back to Marquise, where the train took them back once more to Boulogne, late in the evening.

SATURDAY.—The party went by train to Pont-de-briques, and then walked to St. Etienne-au-Mont. At the top of the hill, Wealden iron ores, sands, and clays are quarried. Dr. Barrois spoke of the conditions of the Lower Cretaceous of Boulonnais as compared with those of the Weald of Kent; Mr. J. Parker

pointed out the resemblance of the Wealden beds of St. I with the sands and iron ores on the top of the Oxfordshire

The party, notwithstanding the rain, which fell very heavil tinued the section to Ecaux, where several diggings for ii were seen. M. Pellat has found *Cyrenæ* and *Trigoniæ* in tl ore, and thinks it to be of Portlandian age.

From Ecaux the Members proceeded to the Alpreck Light where the equivalent of the Portland Stone is very fossil They then returned to Boulogne by the top of the cliffs, wh beds N[1] and N[2] are quarried : *Am. Portlandicus,* wave and markings, are found.

This trip was the last one of the first foreign Excursion Association. Before leaving Boulogne, the Members Geologists' Association invited to dinner the French Dire the Excursion. The terms were very friendly; numerous were proposed to Professor J. Morris, Dr. Foulerton, and Directors of the Excursion. The party sailed from Boulo the evening boat, leaving amongst their French friends tl remembrance of the time spent together, and the pron coming back again before long.

ORDINARY MEETING, 1st NOVEMBER, 1878.

Professor J. MORRIS, M.A., F.G.S., President, in the Chair.

The donations received since the previous meeting were announced.

The following were elected Members of the Association:—

Charles Faulke-Watling, Esq.; and F. W. Harmer, Esq., F.G.S.

The following Paper was read:—

ON THE CONTROVERSY RESPECTING THE GNEISS ROCKS OF THE NORTH-WEST HIGHLANDS.

By WILFRID H. HUDLESTON, M.A., F.G.S., &c.

It is well-known to most of you that Geology formerly had to struggle hard for a position amongst the sciences. The truths, which are now more or less clear to us all, have been combated with a vigour and animosity in direct proportion to the prejudices which assailed them, nor was it quite evident at one time to which side victory would incline. That was a period when Geology was militant, and in that character the meetings of its disciples became the arena where scientists and theologians, of a combative disposition, were glad to disport themselves; and the public, always anxious for a fight, testitied its interest in these discussions by the numbers flocking to hear them. But those days are over: Geology is now a science triumphant, and, as Professor Huxley has lately remarked, the theatre of war is transferred to the department of Anthropology.

Those who are really interested in Geological Science—and the number of these increases every year—need not care for this. Yet it must be allowed that the general public, especially in Scotland, if I may quote my recent experiences, take less interest in geological questions now than formerly. As an instance, I may adduce the fact that the leading Scottish journal of the day, in reporting the Proceedings of the late meeting of the British Association at Dublin, gave but little account of Geological Papers, on the ground that they were of a purely technical character. This indifference of the North Briton may, perhaps, be accounted for in the circumstance that every trace of theological geology has long since been banished from these discussions.

Admitting, however, that Geology has gained a position whi places it beyond the criticism of the general, but more especial of the theological public, there are several questions *unsolved*, eve in solid geology. Those questions which relate to what I ma term the far end of the geological scale, viz., to Archæan Geology have attained considerable importance of late. This, of course, ha partly arisen from the fact that there seem to be no new fossiliferous formations to conquer in this country, whilst people get tired o the cockles and periwinkles of those, which have already, as they may fancy, been exhaustively demonstrated. Thus matters gc very much according to fashion, and hence it comes to pass that Petrology, treating as it does of the structure and composition of rock masses, is a branch of geological science that of late has beer much cultivated. As a natural consequence, the presumably older and more obscure formations have attracted much attention, and the written opinions of even the highest authorities respecting the rocks composing them have been called in question. At the presen moment it may be said with truth that the controversy extends to a considerable portion of the *pre*-Carboniferous rocks of the Britisl Isles.

Such being the case, it is not to be wondered at if we occasionall find an old and buried controversy resuscitated; and in this way i happened that, in the month of April last, our friend, Dr. Hicks dug up a hatchet, which had been buried for well nigh twent years, in the north-west of Scotland. This, then, brings us to th consideration of the subject alluded to in the Circular, viz., the ag and character of the numerous Gneissoid rocks of the North-We Highlands. The discussion, it is true, more or less affects th greater part of the Highland area, but on the present occasion is proposed to deal only with the country north of the Great Gle and principally, in fact, with a long and narrow strip in the We of Sutherland and Ross, having an extent from N.N.E. to S.S.W of about 100 miles.

Before directing your attention to this region, we should ju cast a glance at the views held with regard to Highland geolog during the earlier half of this century. Nowhere was the scienc cultivated with more ardour than in North Britain during th period, and it was, of course, an article of faith with most Scottis geologists, that the Gneiss rocks of "Auld" Scotland were tl

most ancient in the British Islands; indeed, they may be said to have been almost as much interested in the antiquity of their rocks as in that of their own pedigrees. Even Hugh Miller, in one of his works, can hardly refrain from a chuckle of satisfaction on the reflection that the Highland rocks were Britain's first born. This was, more or less, the faith, not only of the worthy North Britons, but of everybody else, till about twenty years ago, when, like almost all other faiths, it was destined to receive a rude shock. And the man who cast this aspersion upon the pedigree of his country's rocks was himself a Highlander, and his associates and accomplices Scotchmen of great geological eminence.

In order to understand the controversy waged by Murchison assisted by Professors Ramsay and Geikie, against the previously-accepted views, which found a champion in Professor Nicol, it will be advisable to notice some of the writers who, previous to this period, allude to the Gneiss of the North-West Highlands, or to the Red Sandstone and Quartzite Rocks, so intimately associated with it.

The English traveller, Pennant, in the eighteenth century, deceived by their external aspect, described the great quartz mountains of the north-west as formed of white marble, but Williams, in the "Natural History of the Mineral Kingdom," spoke of them as formed of granular quartz. In 1819 Macculloch's great work on "The Western Islands of Scotland," appeared. That author paid especial attention to the Gneiss, and is very graphic in his description of the style of country produced (p. 80) by that of the outer Hebrides, so superior in its powers of resisting destruction to either granite, mica-slate, or quartz rock. Its freedom from fissures produces a comparative absence of precipitous faces, and to the same cause the want of springs, characteristic of these islands, is due. His synopsis of Gneiss (p. 228) very briefly abstracted, may be useful:

First division.—Of regular composition, containing, at least, three of the four minerals, quartz, felspar, mica, and hornblende.

Section 1.—Granitic. Of most frequent occurrence in the islands.

„ 2.—Schistose. Principally on the mainland, graduating into micaceous schist, an quartzrock.

„ 3.—Laminar.

Second division.—Of irregular composition, containing compacted and compact felspar, united to some of the ordinary ingredients of gneiss—Felsitic variety.

Third division.—Of irregular composition, being deficient in the number of ingredients of gneiss, or containing some substance not included in that definition. This last is, of course, the exhaustive division, which includes those varieties which are shading off into other kinds of rocks, such as mixtures of felspar and chlorite schist, &c. These three divisions of gneiss are, Macculloch says, united into one group by analogy and geological connections.

In 1828 Sedgwick and Murchison together finished their inspection of the north coast, and Sedgwick appears to have been satisfied that the eastern gneiss did overlie the quartzite and limestones of Loch Erribol. In 1839 Cunningham, in the Geognosy of Sutherland, stated his opinion that the great central gneiss, which overlaid the limestone of Loch Erribol, was more recent than that of Cape Wrath. In 1851 Hugh Miller tried to show that the conglomerate of Cape Wrath, resting upon what will presently be described as the fundamental gneiss, was the base of the Devonian, or true Old Red Sandstone, whilst the quartzite with limestone of Durness and Erribol represented its middle and upper beds, corresponding to the sequence in Caithness. Towards the end of 1854 the great discovery of Silurian fossils in the limestone of Durness was made by Mr. Peach, and this gave additional zest to the investigations of Murchison and Nicol, who seem to have worked together about this period.

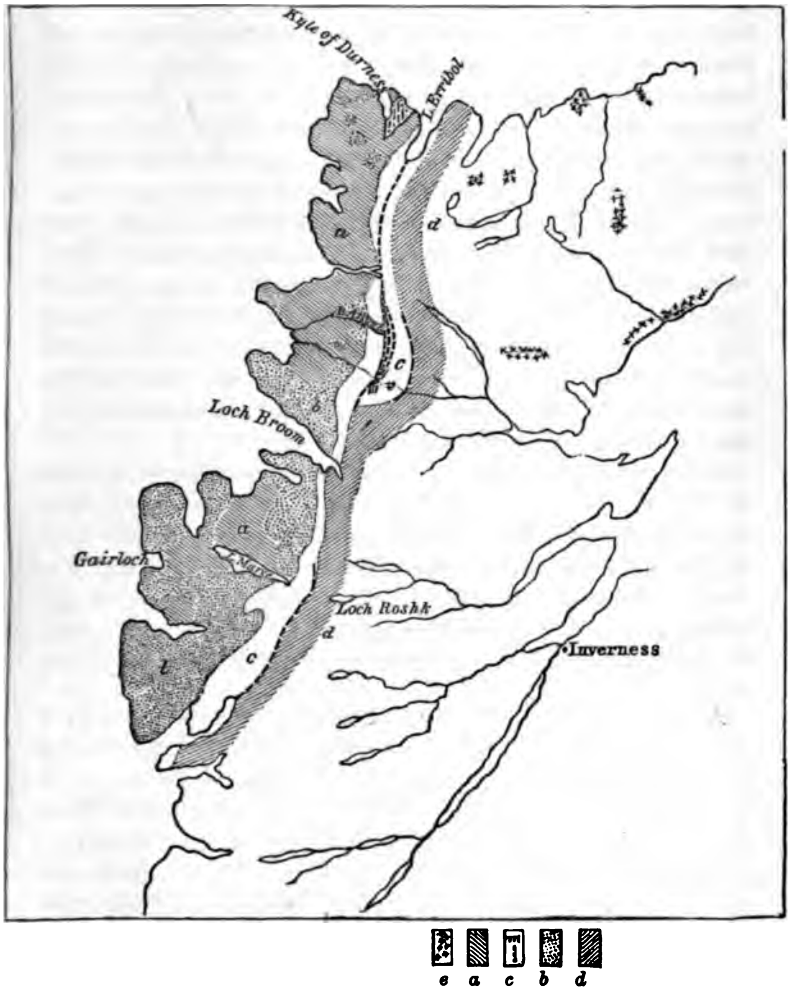
The above may be taken as a rough outline of the history of geological enquiry as to the gneiss and associated rocks of the north-west Highlands, previous to the appearance in the Quarterly Journal of the Geological Society of the remarkable series of papers, which ultimately assumed such a controversial character.

The first of these, by Professor Nicol, on "The Red Sandstone and Conglomerate, and the superposed quartz rocks, limestones, and gneiss of the North-west of Scotland," appeared in 1856. The introduction contains such a graphic description of the district that I venture to transcribe a portion for your information:—

"The mountains (of Red Sandstone and Quartzite) rise abruptly from the great table-land of lower hills (Fundamental Gneiss) in smooth, rounded cones, spiry peaks, or long serrated ridges, their hoary summits shining in the sun, like newly-fallen snow, and

FIG. 1.

GEOLOGICAL SKETCH MAP OF THE NORTH-WEST HIGHLANDS AFTER MURCHISON AND GEIKIE.



e. "Igneous."
a. Fundamental Gneiss.
c. Quartzite with Limestone.
b. Cambrian Grit and Conglomerate.
d. Eastern Gneiss.

N.B.—The thin bands, of "igneous" rock, which more or less prevail in connection with the Quartzite and Limestone Series are not shown.
The Gneissose and Micaceous Series *d* extend far to the eastward.

sending down streams of rugged fragments to the deep sea-lochs that wash their bases. They are found to consist, not of granite or igneous rocks, nor of the older so-called primary strata, crushed up and broken by some great convulsion, as their singular outlines might have led us to expect, but of stratified rocks, lying almost horizontally in thin even beds, and moulded into these strange forms by the slow agency of natural causes." Important sections are given, afterwards to be corrected, and not, according to Murchison, improved, and the order of succession was thoroughly established (page 32), viz., Gneiss, Red Sandstone, Quartzite and Limestone. Although Hugh Miller might have protested, had he been alive, this order is so obvious that it has never since been controverted. Nicol's last conclusion is important in its bearing upon the subject of the controversy about to arise, viz., "that the general dip, though at a different angle, both of the red sandstone and quartzite, is to the south-east, and that at many points on its eastern side *the quartzite and limestone have been ascertained to dip under gneiss inclined in the same direction.*"

The controversy may be said to have commenced in earnest in 1858, when Murchison read his first great paper at the Geological Society, "On the Succession of Rocks in the Northern Highlands," accompanied by a new geological map of the north of Scotland, subsequently corrected up to 1860. This forms the basis of Prof. Geikie's recent map (1876) from a portion of which the one on the wall has been enlarged (sketch map; Fig. 1, p. 51) —

A summary of the conclusions at which Murchison had now arrived, may be gathered from a study of his first diagrammatic section (Fig. 2).*

Since his first discovery, Mr. Peach had obtained additional fossils from Durness, and the entire series is described and figured in the paper (Q. J. G. S. Vol. xv., p. 374), by Salter. Although Nicol was at one time inclined to suppose that these limestones were of Carboniferous age, he had yielded to this evidence, and no palæontologist has ever since expressed a doubt of their being Lower Silurian. Hence, if the above diagrammatic section be a correct summary of the facts of the case, there is a conformable upward sequence between the Silurian limestones with their associated quartzites, and the crystalline schists, *d*, which cover such an ex-

* Reprinted, together with all the subsequent cuts, by the kind permission of the Council of the Geological Society.

tensive area in northern Scotland. This, then, is the point at issue. Are these flaglike gneissoid rocks, *d*, really younger than the Silurian limestones to the westward? Murchison says without doubt they are, and his views were subsequently corroborated by Professors Ramsay, Geikie, and Harkness. From an inspection of the sketch map we may gather that, for a length of one hundred miles or more, the formation *d*, which will henceforth be alluded to as the Eastern Gneiss, abuts against rocks which are held to be undoubtedly Silurian, and a most singular circumstance it is that throughout this long outcrop there should not be abundance of sections capable of showing *beyond dispute* the stratigraphical relations between the two. For to stratigraphical relations all others of a petrological character must necessarily be subordinate. The explanation of the difficulty may be sought—1, in the amount of superficial accumulations; 2, in the complex dislocations of the region; and, 3, in the frequent occurrence of igneous, or apparently igneous rocks in critical situations, whereby the sequence is, or seems to be obscured. To this latter cause Murchison frequently alludes, and we shall see in the sequel that he complains of Nicol attaching too much importance to it.

The details of the stratigraphical facts, together with the petrological and other descriptions of the several rock masses involved in the controversy, may be gathered from the paper by Murchison, above alluded to, from the supplemental notice, which appeared in the following year, and from a most elaborate paper by Murchison and Geikie, in 1861. During this period Murchison sought and obtained the confirmation of his views at the hands of other geologists, and those views may be said to have developed as he went along, always bearing in mind the criticisms of the opposite party, and occasionally replying to them. It will be most convenient, on the present occasion, to deal with the subject topographically as regards Murchison's three papers, making such selections from his descriptions and sectional illustrations as the limited time will admit of. We will then proceed to compare these with Professor Nicol's opposition paper, which appeared in 1860, and consider some of his rival sections.

Firstly, however, we must glance at the character and general relations of the several groups of Rocks within the area, according to the views of Murchison; and here I would again direct your attention to Fig. 2.

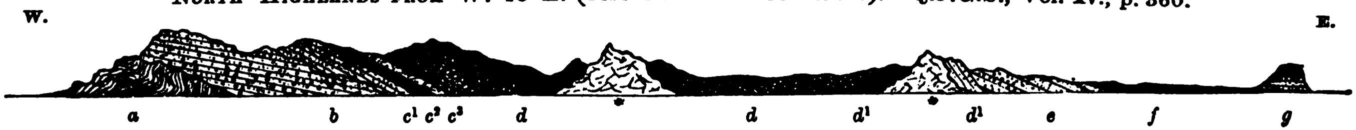
1. *The Fundamental Gneiss.*—The island of Lewis consis almost entirely of this rock. At Morsgail Murchison describes as consisting of indefinite alternations of highly inclined da hornblendic and whitish quartzose laminæ, diversified with pr trusions of highly crystalline hornblendic rock ; and elsewhere a highly crystalline, grey, quartzose gneiss. In some cases t felspar of the old gneiss contains a considerable admixture of lin whose decomposition produces a calcareous cement. The strike north-westerly, or at right angles to the trend of the hills, a geographical axis of the island. "Macculloch, even in his daj says Murchison, "had so faithfully delineated the essent mineralogical distinctions between the gneiss of the Western Isl and that of large tracts of the main land to the east," as to ha prepared the way for those coming after. Murchison furtl observes "that no geologist can confound the Laurentian, fundamental gneiss with the so-called gneiss of the superi crystalline schists," the former being hornblendic and granitoi the latter flag-like, micaceous, and quartzose. He further sa that the gneiss of Loch Maree is the same hard, massive, a highly crystalline rock. The general strike of this underlying fundamental gneiss on the mainland is north-westerly, or ratl N.N.W., but at Cape Wrath, where these beds are splendic exposed, the strike is said to be north-easterly,* the strata bei inclined at high angles, and much contorted. The body of the ro here is usually hornblendic, and penetrated by granitic veins darker grey colours, and of greater specific gravity.

2. *Red Sandstone and Conglomerate* (*Cambrian*).—The Cambri Conglomerate of the Lewis, forming a narrow strip along the Min is made up of large fragments of the subjacent gneiss. This, Murc son considers, to have been the western or shore side of an extensi trough of deposit, and out of these rocks the channel, called t Minch, dividing the Lewis from the mainland, has been excavat On the mainland of Scotland this formation is at present ve irregularly distributed in the N.W. of Sutherland, occurring isolated patches upon the fundamental gneiss, so that in ma places the quartzite, which is the succeeding formation, re directly upon that gneiss, the Cambrian rocks having suffer

* This abnormal strike of the fundamental gneiss is further confirmed John Miller, of Thurso, who says that the gneiss, intersected by veins granite, dips at a high angle to the south-east.—"Q. J. G. S.," Vol. xv., 580.

FIG. 2.

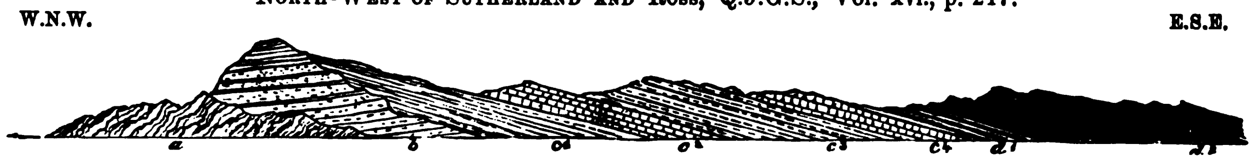
MURCHISON, 1858.—DIAGRAMMATIC SECTION, SHOWING THE GENERAL SUCCESSION IN ASCENDING ORDER ACROSS THE NORTH HIGHLANDS FROM W. TO E. (DISTANCE ABOUT 85 MILES). Q.J.G.S., Vol. xv., p. 360.



a. Fundamental Grey Gneiss with Red Granite veins. *b*. Chocolate and red-coloured Cambrian Conglomerate and Sandstone. *c*. Lower Silurian Rocks, consisting of c^1, Quartz Rock, with *Annelides*; c^2, Limestone with Fossil Shells; c^3, Capping of Quartz Rock. *d*. Crystalline Schists and Flagstones, occasionally chloritic and micaceous, often quartzose, and sometimes constituting flag-like Gneiss. * Igneous Rocks of varying character, interstratified and contemporaneous, or eruptive. Large-grained Porphryry below *a* and *b*; Greenstone with Serpentine in c^2; Syenitic and Porphryitic Rocks protrude between *c* and *d*. These and true granites burst through *d*, which is altered (d^1) in contact. *e*, *f*, *g*. Members of the Old Red Sandstone of Caithness.

FIG. 3.

MURCHISON, 1859—DIAGRAMMATIC SECTION SHOWING THE GENERAL SUCCESSION OF THE ROCKS IN THE NORTH-WEST OF SUTHERLAND AND ROSS, Q.J.G.S., Vol. xvi., p. 217.



a & *b* as in No. 2; c^1, Lower quartz rock with *Annelides*; c^2, Lower Limestone, fossiliferous; c^3, Upper quartz Rock, with *Orthorceras* and *Annelides*; c^4, Upper Limestone; d^1, Uppermost quartz rock passing into micaceous schists; d^2, Gneissic and micaceous flagstones.

denudation previous to the deposition of the strata now n succession. These beds have, on the whole, a strike from I to S.S.W., with extremely moderate dips, being almost hor in places. Though enormously developed in the N.W. of shire, where they seem to have been less denuded, these ro where advance more than a few miles into the interior of the land; hence, they may not be expected to underlie the gneiss for any distance, and that rock, would, therefore, much the nearer to the underlying formations. The gri sandstones composing it are described as being very little me phosed, and in the Hassac glen, north of Loch Maree, the beds are said to be composed exclusively of gneissic frag including much white quartz and felspar, many of the fra being small pebbles, as in the specimen exhibited, which from this locality.

The formation gives rise to some magnificent scenery; Nicol's description has already been quoted, and this applie particularly to N.W. Rossshire, where the mountains comp it are massive and frequently capped by quartz. In Sutherl destruction of the rock has been far more extensive, and h given rise to a series of isolated mountains, as may be seen pictorial representation of Canisp (2,780 feet), Suilven, an more. Hugh Miller's description is so truthful, and so poet I venture to reproduce a portion, as transcribed by Mu "Rising over a basement of rugged gneiss hills, that pres appearance of a dark tumbling sea, we descry a line of stu pyramids, from 2,000 to 3,000 feet in height, which, though miles distant in the background, dwarf by their great nearer eminences into the mere protuberances of an uneve Their mural character has the effect of adding to their a magnitude. Almost devoid of vegetation we see them b the line of the nearly horizontal strata, as edifices of man tion are bared by thin courses of dressed stone; and, whil of their number, such as the peaked hill of Suilven, ris angle at least as steep and nearly as regular as that of an E pyramid, in height and bulk they many times surpass the Egyptian pyramid." Hugh Miller then goes on to show h deep red colour of these rocks is contrasted with the co stone of the gneiss tract beneath. In the depression l Canisp and Suilven is a band of red porphyry, with large cry

felspar, and Murchison notices how one of the earliest coarse sedimentary accumulations in the crust of the globe seems to have been ushered in by the eruption of porphyry, associated with red conglomerate—a phenomenon repeated at intervals in palæozoic times. This Cambrian Sandstone is, in some places, a sort of arkose, or *remanié* granitoid rock.

3. *The Quartz-rocks or Quartzites* (*Lower Silurian*). —The lowest beds repose upon Cambrian conglomerate, or, in its absence, upon the fundamental gneiss. The prevailing dip is E.S.E., as of all the overlying series. The rock has much the character of the well-known Stiper Stones, and is evidently only an altered sandstone, being regularly bedded and jointed, and exhibiting argillaceous wayboards, which have usually passed into shales or schist. It consists of fine siliceous grains, is for the most part void of mica, and often not harder than some siliceous sandstones of the Scottish Coal Measures in the vicinity of trap; and is disposed in regular beds of moderate thickness, with ripple-marked surfaces and false stratification. Moreover, Nicol says that the thinly laminated blue and grey shales, interbedded with the more massive siliceous rock—the wayboards of Murchison—are full of carbonaceous plant-like impressions, and strongly impregnated with iron. These bands further resemble the Stiper Stones in containing Annelide-tubes and Fucoids, which latter are especially abundant in the uppermost layers of the lower band, and also immediately below the limestone, where the bed containing them occupies a prominent position in Nicol's sections.

Although the Quartzite series is magnificently developed throughout the entire length of the area under consideration, it seems to occupy more accessible situations in the Assynt country, where Murchison, in his second paper (1859), states that there are no less than three sets of quartz rocks, separated by two limestones. The well-known frontispiece to Siluria represents the noble sweep of the Quartzite from the chocolate-coloured sandstones of Quenaig (2,673ft.) towards the hollow occupied by Loch Assynt. Here the Cambrian sandstone of the mountain dips to the W.N.W. at an angle of 5° on which are superposed sheets of compact quartz rock dipping from 20°-25° to the S.E.

Murchison's second diagrammatic section (1859), across the counties of Sutherland and Ross (Fig. 3) gives a summary of his results as obtained chiefly along this traverse, showing the whole Silurian series dipping away from the Cambrian conglomerate,

as seen in the less detailed diagram, Fig. 2. Here the autl lays particular stress upon the double series of quartzites, t double series of limestones, and a third or uppermost quartz rc passing into micaceous schists and gneissic micaceous flagstoı —the Eastern Gneiss of the controversy—the whole dipping the S.E. As this is confessedly a generalised section, all di culties, such as faults, protrusions of igneous, or extravasated ro &c., are left out. The local sections in Assynt are so numerc so complex, and involve so much topographical detail, that diagrammatic summary must be taken for granted, until we cc to consider the very different stratigraphical interpretation of region given by Professor Nicol (Fig. 7).

4. *The Limestones* (*Lower Silurian*).—These are descri generally as blue or grey limestones, alternating with sha and in some places black, bituminous, and emitting a fetid od(But they are also hard, marbled, veined, and often highly silicec Not only does the limestone in parts assume a cherty charac but in Durness it is filled with a profusion of geodes of chert quartz. Even in its siliceous condition the limestone occasion retains an oolitic structure. The best limestone (Durness) is i state of cream-coloured compact marble, but no fossils have b discovered in that variety of the rock. The fossils, princip *Maclureæ*, *Murchisoniæ*, and *Orthocerata*, occur in dark colou cherty, and very fetid limestone. Even where the rock is conce the grassy character of the vegetation, affording the strong c trast of a smooth green sward, so rare in these heath-clad regi will serve to indicate its presence. The Durness basin is almost only place where fossils, other than Annelides and Fucoids, l been discovered in the quartzo-calcareous series. One Orthocerɛ is quoted from the limestone of Assynt, and a similar fossil f the quartzite of Loch Erribol. South of Assynt nothing whate except these Annelides and Fucoids, appear to have been foun any part of the series. In some places the limestone is stated t 500 or 600ft. thick (Durness), but is extremely variable in development, as we shall perceive subsequently, and at many po in the long line of its outcrop is strangely associated with a soı igneous rock, which so often seems to obscure the upward seque when a natural section is affording the long wished for opportu of determining whether the limestone really is succeeded confo ably by the eastern gneiss or not.

5. *The "Igneous Rock" Associated with the Limestone* (see

notes explanatory of Fig. 2) is well worthy of close attention. It figures very conspicuously, as we shall see, in Nicol's sections, less so in those of Murchison. Professor Nicol, when stating his belief (1856) that the Eastern Gneiss might possibly be a metamorphic group newer than the Lower Carboniferous system of Scotland, even then appears to have had his eye upon this irregular band, which seemed to afford him a hope of escape from the terrible conclusion, so shocking to the feelings of a patriotic Scotchman, that the great mass of his country's gneiss was a mere upstart in time, which had palmed itself upon geologists as of high antiquity. This hope was no less than the supposition that the aforesaid igneous rock had followed an enormous longitudinal fissure which brought up the lower, or Western Gneiss, into a position, seemingly above the quartzo-calcareous series, and that thus the eastern or apparently upper gneiss was the real old gneiss, with a fresh dip and strike. Cunningham had noticed this "igneous rock" in the neighbourhood of Loch More, as composed of compact felspar and quartz, but described it also as a gneiss. It is evidently associated in some way or other with the strike of the quartzite with limestone, and appears sometimes interbedded, sometimes across the bedding; in some places interferes with the dip of the associated beds, in other places not so; thins out to a mere string, or widens out into bosses, producing picturesque crags (Craig-na-feolin, for example) all the way from Whiten-head to the Sound of Sleat. Lithologically, Nicol describes its representative near Loch Erribol as a mixture of compact felspar and quartz, often with an imperfect laminar structure, having hornblende, talc or scales of bronzite occasionally intermixed, and this is probably the kind of rock so often spoken of by Murchison as syenite. In other places, according to Nicol, it passes into a distinct crystalline binary granite of orthoclase and quartz, or into felspar-porphyry, or diorite, and, where in contact with the limestone, into a kind of serpentine. Yet with all this diversity it exhibits a community of character more easily recognised than described. As this rock evidently plays such an important part in confusing the geological structure of the country and the sequence of the beds, it may be looked upon as one of the prime authors of the controversy with which we are dealing on the present occasion, and as such will necessarily attract more of our attention.

6. *The Eastern Gneiss* (*Silurian* according to Murchison; the

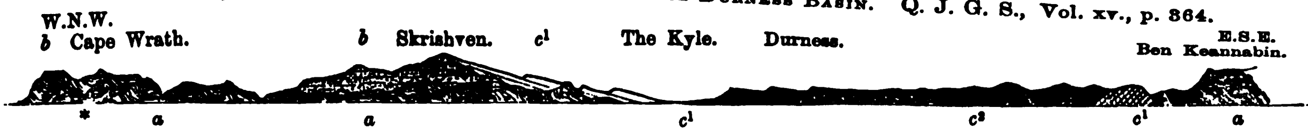
Old Gneiss repeated, according to Nicol). The lithological di similarity of structure with that of the Western Gneiss has be already partially indicated, and is frequently insisted on by Mu chison. The lower portions are very quartzose, mica being almo absent, but in the higher masses that mineral begins to preva: The series may be said to pass from quartzose flagstones in chloritic and micaceous schists, and thence into a sort of gneis As, however, it is the position and character, and by consequen the age of this rock, which forms the principal subject of the co troversy, we must gather these from the numerous *detailed* sectio about to be quoted. Before examining these witnesses of t respective theories, it will be as well just to revert to the positi which Murchison now took up, and of which we have already h an intimation in the diagram (Fig. 2).

Murchison maintained that the upper, or Eastern Gneiss, whi he describes as a great mass of micaceous flag-like and young gneissose rocks, extends for the most part across Sutherland, in easterly direction. Intruding masses of granite rock, howev like the band of "igneous rock" already mentioned, but of mu greater volume, penetrate the crystalline strata more or less alo two lines, as indicated in Fig. 2, and he points out the pc sibility of the fundamental gneiss being brought up again the vicinity of these; frequently indeed throughout all his pape he seems to have expected that such would be the case.* Co fining ourselves to Sutherland and the borders of Caithness, t first of these eruptive lines is marked by the syenite masses Ben Laoghal and Ben Stomino, the second by the mountaino fringe from Strathy to Tomentoul, and thence southerly towar the granitic mass of the Ord of Caithness. This latter not on penetrates the crystalline strata, but throws off the real Old R Sandstone, the strike of which appears to be in complete di cordance with that of the crystalline rocks, which it overla unconformably, and from which it is sharply separated. W have then, sums up Murchison, a great group of rocks betwe the Cambrian conglomerate on the west and the true Old R Sandstone on the east, which on the whole are conformable each other in strike, dip, and undulations, and whose lower me bers contain Lower Silurian fossils. The inference was that t whole group, with the exception of the granitic intrusions, a

* Attention should be drawn to Murchison's views on this point.

FIG. 4.

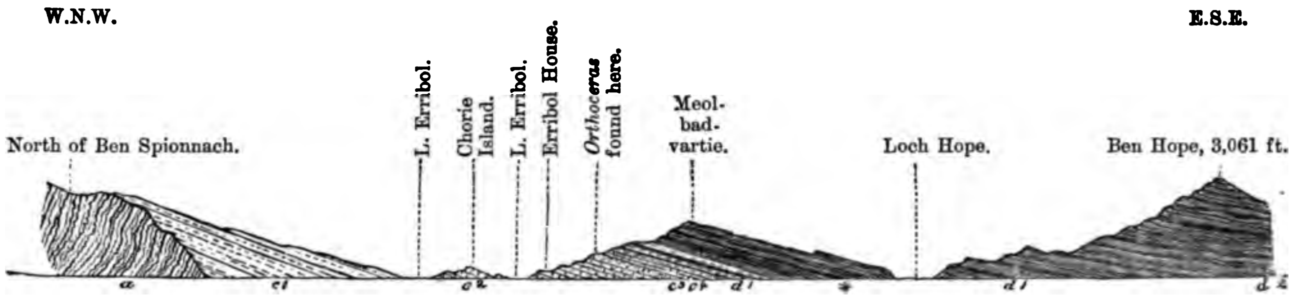
MURCHISON, 1858.—TRANSVERSE SECTION ACROSS THE DURNESS BASIN. Q. J. G. S., Vol. xv., p. 364.



a, Fundamental Gneiss of Cape Wrath and Ben Keannabin; *b*, Cambrian conglomerate and Sandstone; c^1, Quartz Rock; c^2, Durness Limestones with Lower Silurian Fossils.

FIG. 5.

MURCHISON, 1859.—SECTION ACROSS LOCH ERRIBOL AND LOCH HOPE. Q. J. G. S., Vol. xvi., p. 226.



a, Fundamental Gneiss North of Ben Spionnach; $c^{1\,2\,3\,4}$, Quartz Rocks and Limestone; d^1, Micaceous and Quartzose Flagstones; d^2, Micaceous and Gneissose Flagstones; * Intercalated Igneous Rock.

such rocks as they might have brought up with them, must clearly be Silurian, from Cambrian Old Red on the west to Devonian Old Red on the east.

Nicol had at length, as we have seen, admitted that the quartzite with limestone was Lower Silurian, but had doubted its passing under the micaceous flaggy rock. In fact, the great line-of-fault theory, of which we had previously seen an indication in 1856, had now come into full leaf, and he maintained that outbursts of igneous rock, connected with a general dislocation along the strike, had brought up the old gneiss on the east. The appearances in the Erribol district and at the head of Loch Maree were, he held, especially favourable to his views.

But, says Murchison, such protrusions of igneous rock occur irregularly in different beds, and vary according to the rock they penetrate, though the eruptive matter is very likely to peer out here and there along the lines of least resistance. He then proceeds to give details of the sequence immediately to the east of the Assynt country, where the eastern gneiss is regular in its E.S.E. dip, and mineral characters; but if the line of section be deflected towards the north (Lairg), the micaceous series being invaded by granite, alteration produces a gneiss like that of the west coast. But a steady dip of 20°, extended over so large a tract of country might produce an objectionable thickness of rock, and Murchison meets this difficulty, 1, by supposing that the micaceous flags may have been deposits in the same sea but at some distance from the bottom rocks, and, though apparently overlying them, may be almost a contemporary formation; 2, by innumerable curvatures, breaks, and repetitions, as on the mountain Aigean,* near Loch Fannich, where thin-bedded grey, quartzose gneiss is seen to be dipping W.N.W.—whilst the country to the east is much faulted and broken up. Finally, he says that the general view of the succession must be tested by making traverses in the northern counties, from N.W. to S.E., and by marking the manner in which one group succeeds another.

Both Murchison and Nicol have done this at various points along the extended line of strike; and to a few of these sections I would now direct your attention.

It will occur to every one that the extreme north coast of Sutherland, being nearly at right angles to the mean strike of the

* About six miles E. of Ben Fyn, and forming part of the same range.

lurians, would exhibit some very conclusive sections; but it is ident that the results vary considerably according to the direction here the line is taken. One of the most interesting of Murchison's ections is that across the Durness Basin, and the chief interest ere lies in the fact that this is the only place, according to Murhison, along the whole line of strike where the Silurians do lie in basin, the Fundamental Gneiss actually coming up again on the eastward in the mountainous ridge which terminates in Ben Keannabin. The folded and fractured limestone is held in a trough of quartzite, which itself is troughed in the Fundamental Gneiss, just as Nicol says occurs along the whole line. No eastern or flaggy micaceous gneiss appears in this section, but so complex is the faulting of this district, that if the section had been drawn more towards the mouth of the Kyle of Durness, we should see the Eastern or upper gneiss on the west side of the quartzite with limestone, let in by a fault, whilst the Western or lower gneiss is brought up on the east side by a fold.* Each, therefore, is out of its place, and the section from Cape Wrath to Loch Erribol, a distance of about 14 miles, cannot be considered decisive of the point at issue. Of this exceptional state of things Professor Nicol could not fail to avail himself, and he accordingly gives a section of a portion of the coast, from the Kyle of Durness to Loch Erribol, of just sufficient length to show the two gneisses in their reversed positions; and he thus places the micaceous Eastern Gneiss of Far-out Head in the same category with the high-dipping and contorted gneiss of Ben Keannabin, which is everywhere penetrated by veins and masses of red granite and hornblende rock, and has evidently been tilted up on the west side since the deposition of the quartzite. He admits, however, that in dip and mineral character the micaceous gneiss of Far-out Head is quite identical "with the mica-slate on the east of the quartzite at Loch Erribol." Murchison (1861) criticises the inaccuracy of the bearings of this section, and shows that owing to this error the strata are necessarily placed in false positions.

The ridge, of which Ben Keannabin is the northern termination separates the vale of Durness (Strath Dionard) from the great hollow in which Loch Erribol is placed; it culminates in Ben

* On account of the small scale of the sketch map (Fig. 1), it is not easy to show this clearly; but the headland which occupies the east side of the Kyle of Durness is held to consist of the Eastern Gneiss, *d.*

Spionnach (2,566 feet), and appears to consist throughout of the highly inclined and contorted Fundamental Gneiss, like that of Ben Keannabin.

Fig. 5, selected from Murchison's paper (1859), gives what may be termed the east-south-easterly prolongation of the section across the Durness Basin (Fig. 4), but on a more southern parallel. Having now surmounted the great fold which repeats the Fundamental Gneiss in the Spionnach-Keannabin ridge, the exceptional state of the Durness Basin no longer obtains, and, if the interpretation, confessedly very much generalised, given in Fig. 5, be correct, the sequence from the quartzite with limestone of Loch Erribol through the complex masses of the intervening ridge into the micaceous and gneissose flagstones of Ben Hope is complete. This ridge between Loch Erribol and Loch Hope is a regular battlefield of rival sections and descriptions between the contending parties from Whiten Head southwards. Throughout its length a manifestation of the peculiar "igneous rock" previously described—the syenite or porphyry of Murchison, the granulite of Nicol—is present, now threading its way through the stratified quartz rock and overlying schists which compose that magnificent headland, now thinning out to a partial and evanescent layer of felspathic matter a few feet thick, and then swelling out again into picturesque bosses, such as that of Craig-na-feolin, towards the head of Loch Erribol itself. Nicol tries hard to make the most of this rock, which Murchison admits that himself and Harkness had treated too lightly. Nowhere are the opposing parties more difficult to follow than on this ground, Nicol's sections exhibiting the rocks as flying off in all directions from faults, reversals, and eruptive bosses; whilst Murchison struggles to show that although undoubtedly transgressive in places, and occasionally, as at Drumtungi (? Drium-an-tenigh of Nicol), throwing off the quartzite, this igneous rock, as a whole, does not affect the easterly dip of the strata. Although, says he, these granitic felstones, when followed on their strike, do perform the part of intrusive masses which have been injected into the overlying rocks, and principally into the schists and dark green chloritic flagstones succeeding the quartzite, the ascending order is clear right up to Ben Hope, the whole being one sequence, whether gneiss or mica-schist, which are no more than lithological variations. It is true that the rocks become more really gneissic as we approach the vast igneous intrusions in the vicinity of Tongue; on the flanks of these grand eruptive masses

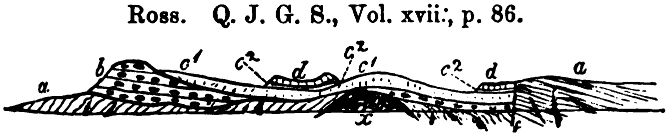
the contiguous strata, though altered, hardened, twisted, and more resembling the older gneiss than any of the flag-like masses round Ben Hope, still maintain their prevalent dip.* He insists, therefore, that it is impossible any longer to confound these rocks with the western or fundamental gneiss, and observes that the term "gneiss," like grauwacké, covers too much, and must be discarded by geologists; and predicts that the day is coming when the various members of the Scottish gneiss will have their true ages assigned to them.

Finally, he quotes the testimony of Professor Harkness, who insists in corroboration of his views, firstly, upon the difference in lithology; secondly, the variance in the strike; thirdly, the undoubted sequence between the quartzite with limestone (admittedly Silurian) and the overlying flaggy gneiss, wherever the surface admits of this being observed; fourthly, that the mode in which the felspar rock (Nicol's granulite) is found in relation to this gneiss at Erribol does not indicate, as Professor Nicol tries to make out, any great line of dislocation, since the bulk of it comes *through* the so-called gneiss, and not *between* it and the quartzite with limestone.

Having thus far principally confined our attention to the generalisations of Murchison as affecting the greatest revolution in Scottish geology, it is time to offer to your notice the interpretation which his antagonist, Nicol, finally put on the perplexing strata of the North-West Highlands.

FIG. 6.

NICOL, 1860.—DIAGRAM-SECTION OF SUTHERLAND AND ROSS. Q. J. G. S., Vol. xvii., p. 86.



a, Crystalline Schists; b, Red Sandstone (Cambrian); c^1, Quartzite; c^2, Fucoid Beds; d, Limestone; x, Granulite or Syenite; f, Fault.

This must be gathered from a study of the accompanying diagram (Fig. 6), wherein his view of the case is set forth. After four visits, and a thorough investigation of the case, Nicol agrees with Murchison in the sequence as far as the limestone, but is prepared to prove that thence there is no conformable sequence into the "younger gneiss," the supposed line of junction being clearly a

* Vol. xvi. p. 236.

line of fault with igneous action. We see, then, that instead of steady easterly dip of Murchison's diagrammatic section (Fig. the quartzite with limestone (*Lower Silurian*) is rolled up as follow it to the east by a longitudinal fold of igneous rock—the called granulite or syenite—whereby the limestone is troughed, is admittedly the case in the Durness district. One side of t trough is again repeated, bringing up the same quartzite and lim stone mistaken by Murchison for a second quartzite and a secon limestone. This is sharply faulted against the Eastern Gneiss, tl fault being, of course, filled with extravasated matter, on the oth side of which we have brought up either the underlying gneiss the west, or, at least, some intermediate gneiss below the base the Silurians. Although both the western and the eastern gne are indicated by the same letter in Nicol's section, the variance strike and dip is made just as obvious as in those of Murchison.

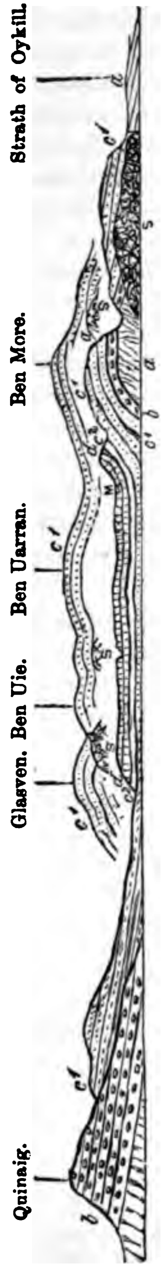
His different interpretation of the north coast section has alrea been mentioned in connection with Fig. 3, as also of the through the head of Loch Erribol (Fig. 4). Very interesting ri sections are also given by both combatants within the area betw Lochs Erribol and Assynt. Time will not permit of our glanci however briefly, at these, but the classic locality of Assynt, familiar to the readers of Siluria, must perforce arrest our att tion for a while.

Fig. 7 represents Professor Nicol's reading of the Ass country, which is remarkable for the great extent and thicknes the limestone associated with the quartzite. Murchison's views familiar to the readers of Siluria, and his generalised section Assynt (Q. J. G. S., Vol. xvi., Fig. 3, p. 217) is accordingly omitt but the summary thus obtained may be gathered from Fig. 3, p 55, wherein he shows two limestones and two quartzites. As additional proof that there is a quartzite above as well as below main limestone, Murchison observes that the lower quartz rocl Canisp weathers white, whilst the upper quartz rock of Ben M with limestone distinctly below it, has a pinkish tinge, and i parts pebbly.

Professor Nicol, on the other hand, declares that the supp upper quartzite is due to repetition, the limestone being thr into a basin ; even the red sandstone of Quinaig and Suilve brought up again actually resting on gneiss, as may be seen in corries of Ben More, thus forming the base of the east sid the Quinaig synclinal (strong dip east of L. Maolach Corry).

FIG. 7.

NICOL, 1860.—SECTION OF ASSYNT. Q. J. G. S., Vol. xvii., p. 96.



a, Gneiss (the Gneiss of Quinaig has granitic and syenitic views); *b*, Red Sandstone (Cambrian); c^1, Quartzite; c^2, Fucoid Beds; *d*, Limestone; *S*, Syenite; *M*, Loch Maolach Corry.

underground drainage, directed as it is, from all sides towards Loch Assynt, the centre of this synclinal, is a further proof—nay, some of the so-called upper quartz rock in Ben More is actually Cambrian sandstone. He also makes much of the igneous rock, though hardly venturing to bring it to the surface in this section. This, of course, produces the usual muddle indicated by a fault. Next comes the eastern gneiss, dipping to the S.E. at a moderate angle, as in Murchison's section. This interpretation is criticised by Murchison,* who declares that he has the confirmatory evidence of three geologists of the passage of the limestone into a superior quartz rock; and he further observes, with reference to the south-east end of the section (Alt Ellag, &c.), that one of Nicol's detailed sections (p. 100) seems to sustain the proofs of the order of succession as pointed out by himself, the only difference being that neither he nor his companions could observe the fault or dislocation which Professor Nicol places between the quartz rock, &c., and the overlying schists.

South of the Assynt country the limestone becomes much thinner, and so continues all the way to Loch Broom, though distinctly traceable along the strike; south of L. Broom it disappears,

* Vol. xvii., p. 229-230.

and the eastern gneiss comes directly upon the quartzite until arrive at the neighbourhood of Loch Maree, where the limesto re-appears in a very interesting and much debated section, to whi a recent paper by Dr. Hicks has drawn renewed attention. Befo considering the various interpretations of the important section the head of L. Maree, I will offer for comparison a much eas section on the borders of Sutherland and Ross-Cromarty, which drawn quite differently in the respective papers of Nicol and Murchison and Geikie in the same volume of the Quarter Journal.

FIG. 8.

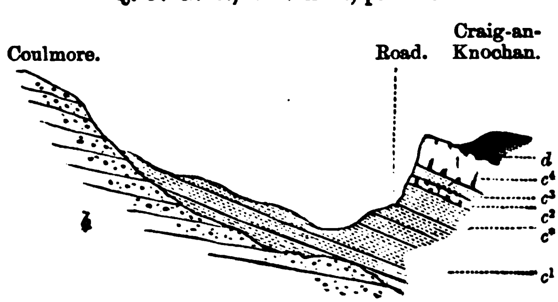
NICOL, 1860.—SECTION ON THE ULLAPOOL ROAD, NEAR ELPHIN. Q. J. G. S., Vol. xvii., p. 101.

a, Gneiss; *b*, Red Sandstone; c^1, Quartzite; c^2, Fucoid beds; *d*, Lim stone; *x*, Granitic vein.

Nicol's description of this section is peculiar, as he seems stick to it only for a while and then to leave it for another li further south, where he can bring in "a thin vein of granite syenite like that on L. Erribol." He comes to the usual concl sion that there is no upward succession, "but a line of fault wi powerful lateral compression."

FIG. 9.

MURCHISON AND GEIKIE, 1861.—SECTION AT CRAIG-AN-KNOCHA Q. J. G. S., Vol. xvii., p. 180.



b, Cambrian Sandstone and Conglomerate.
c^1, Quartz-rock.
c^2, Limestone.
c^4, Limestone.
c^*, Fucoid-bed.
c^3, Quartz-rock.
d, Gneissose Schist.

The limestone escarpment at this point is represented as being from 60 to 100 feet high, the road, which runs upon the white quartz rock skirting its base. The description tallies fairly with the figure, and the authors entertain no doubt that the limestone is regularly intercalated between "a series of white quartz rocks below and a set of quartzose schists (=the Upper Gneiss of previous papers) above." They mention a porphyritic felstone as running parallel to the strike two miles further south, and this is probably the igneous rock which figures in Nicol's section.

Following the outcrop of the quartzite with limestone southwards, Murchison and Geikie give some interesting details in support of their view of the conformable sequence; and with reference to the serpentine in the neighbourhood of L. Auchall, on the north side of L. Broom, quote Nicol against himself. They describe this rock as a porphyritic felstone with jaspery pebbles, and some serpentine near the limestone, as is usually the case.

South of L. Broom the same authors give some very interesting sections, where the upper or eastern gneiss may be seen resting directly upon the quartzite in the absence of the limestone, which is next seen in Glen Laggan, (the Glen Cruchalie of Murchison and Geikie), towards the head of L. Maree.

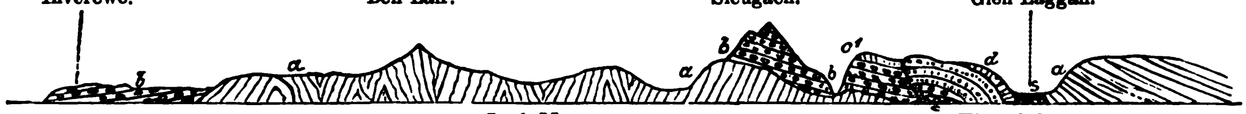
Sections in the Neighbourhood of Loch Maree.

There is very little apparent difference between Nicol's section (Fig. 10) and that by Murchison and Geikie (Fig. 11), except that, being on a smaller scale, the former embraces a greater stretch of country. Everything is here in its place—the hornblendic gneiss of the lower part of the Loch, with north-westerly strike and high dip generally to the W.S.W.; the Red Sandstone and Conglomerate of Sleugach, followed on the east by the quartzite and limestone; the peculiar felspar rock, here called a diorite; and then the easterly gneiss with a north-easterly strike. But for the hypothetical fault in Glen Laggan and some minor details in the massif between that valley and the Hassac Glen, the one would almost do for the other, as may be seen by an inspection of Fig. 11.

As regards the question of sequence between the limestone and the Eastern Gneiss, this is not, on the whole, a very good locality for judging, owing to the great development of the red felspar rock about the junction of the two in the Laggan Valley, where, according to Nicol, it forms a wide mass running up to the valley for several miles. Nicol describes the beds on the

FIG 10.

NICOL, 1860.—SECTION ON NORTH SIDE OF LOCH MAREE. Q. J. G. S., Vol. xvii., p. 104.



a, Gneiss; *b*, Red Sandstone (Cambrian); c^1, Quartzite; *d*, Limestone; *S*, Diorite or Syenite.

FIG. 11.

MURCHISON AND GEIKIE, 1861.—SECTION AT THE HEAD OF LOCH MAREE. Q. J. G. S., Vol. xvii., p. 191.

east side of this as consisting of grey granitic gneiss, in some places more quartzose, in others fine grained and micaceous, dipping 20° E.S.E. on the east side of the fault, though he does not adduce any evidence of its existence, and does not venture to draw it on his section. Murchison and Geikie consider that the position of the red felspar rock (syenite) is variable with reference to the quartzites and limestones, but that it does not interfere with the ascending order, the upper flaggy or schistose beds succeeding conformably as elsewhere. From this they draw the usual inference, that the whole of the Eastern Gneiss is metamorphosed Silurian; and this principle was applied by them so as to include the major part of the Scottish Highlands within that formation.

To this conclusion the following objections on general grounds are stated by Professor Nicol:—1. That whilst for miles we perceive the red sandstone resting on gneiss, the quartzite on the red sandstone, and the limestone, though fragmentary, on the quartzite, yet the Eastern Gneiss in all the long line of strike from N. to S. has nowhere, except for a few yards, even been alleged to overlie the other rocks, nor is any isolated portion of it seen resting on the quartzite or limestone west of the supposed line of overlap. 2. The diversity of strata brought into contact with the Eastern Gneiss is evidence of a fault. 3. The difficulty of truly crystalline metamorphic rock resting on deposits, thousands of feet thick, of unaltered sandstones and limestones with fossils. 4. *Strike of the Beds.*—As regards the argument derived from the diversity of strike, he observes that the relative ages of the gneiss in the two regions east and west of the quartzite, &c., is a different question from whether one of them overlies the quartzite. Still, the distinction is not universal, as exceptional conditions of strike prevail, and in reality the country consists of fragments of strata irregular in form and of more or less extent, each subject to its own laws of position. 5. As regards *mineral characters*, he maintained that there was no such constancy of difference, quoting Cunningham to the effect that these characters were essentially the same. Hornblendic and granitic gneiss are common in parts of the eastern district, but this peculiar character of rock has no reference to age or locality, but only to proximity to the great foci of igneous action. 6, In conclusion, he lays stress on the fact, never denied by Murchison, that we have no proof of the supposed Silurian Mica-slate being inferior to the great mass of granitic gneiss in the centre of Sutherland. Is it not probable, he contends, that the

huge syenite domes of Ben Laoghal and Ben Stomino break the series and bring up anew the lower and older gneiss? He has no hesitation, then, in asking a verdict in favour of the old and long-established principles of Scottish geology.

This was not generally accorded, and the views so ably advocated by Murchison, Geikie, and others seem to have obtained general acceptance both at home and abroad. Thus, in the "Canadian Naturalist" for 1861,* Dr. Sterry Hunt, referring to this controversy, remarks that "In geological structure and age, not less than in lithological and mineralogical characters, the rocks of the Western Highlands are the counterparts of the Laurentian and Silurian Gneiss formations as seen in the Laurentides and Adirondacks, and in the Green Mountains,"† and he further observes that the same parallelism may be extended to Scandinavia.

In this latter country there is such an immense development of Archæan rocks, at no great distance from the Scottish Highlands that the great Gneiss controversy could not fail to excite a deep

* Vol. vi, p. 94.

† "The Green Mountain Gneissic formation, instead of being beneath the Silurian Series, is really a portion of the Quebec group more or less metamorphosed, so that we recognise nothing in New England, or South-east Canada, lower than the Silurian system."—*Loc cit.*, p. 93. Such appears to have been the earliest impression of Dr. Sterry Hunt with reference to the geological age and equivalents of the Green Mountain Gneissic series. These views were re-stated and further developed in a second article (Can. Nat., Vol. *cit.*, p. 374, *et seq.*, entitled "Mr. Barrande on the Primordial Zone in North America, and on the Taconic System of Emmons." At page 378, Dr. Hunt says, "The Gneiss (of the Green Mountains) is a newer rock (than the members of the Taconic system), being no other than the Sillery Sandstone in an altered condition." In continuation he remarks that Emmons had fallen into "an error similar to that of Nicol with regard to the Gneiss of the Scottish Islands," and had been driven "in order to explain the structure of the Green Mountains to admit, not merely an upthrow with Nicol, but a complete overturn of the whole Palæozoic series in question." In the succeeding volume (vii., p. 78), Dr. Hunt writes a short article wherein he maintains his previous opinions with respect to the Green Mountain Gneiss, but admits that Emmons, in spite of his use of the expression "inverted strata," never maintained any inversion or overthrow. In the following volume of the "Canadian Naturalist" (viii., p. 195 *et seq.*), Dr. Hunt writes an important article "On the Chemical and Mineralogical Relations of Metamorphic Rocks," wherein he further developes his views as to the more intense chemical activities of earlier times, and as to the importance of the proportion of alkali in the alumina rocks—a point he has never ceased to urge. At page 204 Dr. Hunt arranges the crystalline strata of North America into groups, viz.—1. Laurentian; 2. Labradorian; 3. Series of Crystalline Schists in Canada referred to the Quebec Group, an inferior part of the Lower Silurian; 4. Metamorphosed strata of Upper Silurian and Devonian age. "It is to be remarked that the metamorphic strata of the third and fourth series are everywhere separated from the Laurentian and Labrador Series by a zone of unaltered Palæozoic rocks."

interest amongst those who studied its geological structure. Amongst these was Macfarlane,* who gives an interesting account of the respective views of the two schools. It appears that there is a large area in Scandinavia occupied by what used to be called "The Primitive Gneiss formation," and which was viewed as the fundamental rock of the country. Both the strike of this and of the transatlantic Laurentian gneiss is, according to Macfarlane, mostly N.N.E., but the dips are more inclined in Norway than in Canada. It is noteworthy that this strike is quite discordant with that of the Scottish Fundamental Gneiss. Keilhau and Naumann maintained that this was the oldest rock of the country, on which rested what was called the Primitive Slate formation (a very variable and comprehensive group), succeeded by Grauwacké Slates and Sandstones, capped by fossiliferous Silurian strata. The opposite school, represented by Kjerulf and Dahll, declared the Primitive Gneiss formation to have no existence whatever,† but to be resolvable into gneiss-granite, which is eruptive and of two distinct ages, and Macfarlane observes that this total obliteration of the Gneiss formation is perhaps the most extreme point to which the supporters of ultra-metamorphism have yet attained. Some of these metamorphosed rocks, such as the "Dovrefjeld Slates," were thus supposed to be closely related to the adjacent Silurian, and the analogy between Canada, Scotland, and Scandinavia deemed to be established. In the Scottish Highlands, Macfarlane says, a schistose series having the lithological characters of the Quebec Group and "Dovrefjeld Slates," has been the subject of much controversy, and Murchison *seems* to have shown that they are really younger than the oldest fossiliferous rocks of Scotland. This author, therefore, renders a somewhat unwilling homage to the new philosophy, and records his opinion that views as to the

* Primitive formations in Norway and Canada—"Canadian Naturalist" (1862), Vol. vii.

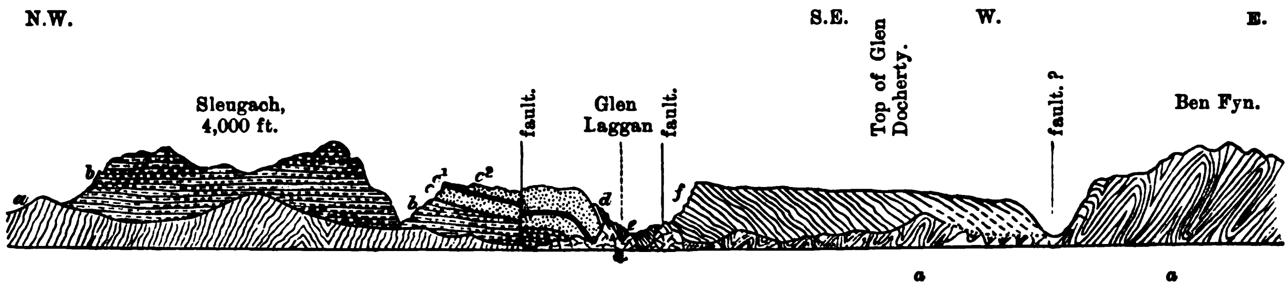
† As this statement is at variance with what we find recorded in Siluria (4th ed., 1867), it is possible that MM. Kjerulf and Dahll may have modified their views; since they are represented (p. 353) as having worked out "fundamental rocks of gneiss and quartzose hornblendic and micaceous slates, which may represent the Laurentian rocks." But we find (p. 346) that this Laurentian gneiss is represented by the widely spread crystalline rocks of Telemark—a region which, when Macfarlane wrote, was supposed to be occupied by the Quartzose group of the Primitive Slate formation. If, therefore, as Macfarlane states, these eminent geologists have done away with one Primitive Gneiss formation, they were not very long, according to the testimony of MM. Murchison and Geikie, in substituting something of the sort in its place.

schistose group will differ until the value of petrographical characters in conjunction with stratigraphical position is fixed; he expresses his conviction that, when the true limits of metamorphism are recognised, the schistose rocks "above referred to" will be found to underlie the Silurian.

Many years have elapsed since these words were written, and whilst in this country few have ventured to question the conclusions of Murchison and his associates, viz., that the bulk of the Scottish gneiss was really of Silurian age, geologists and petrographers have been steadily at work on the great Archæan regions abroad, which it has been proposed to discriminate and classify almost after the fashion of the fossiliferous formations. In this way large areas, which were supposed to consist of metamorphosed sedimentary rocks of Palæozoic age, have been claimed as of far higher antiquity—pre-Cambrian, at least. Our friend, Dr. Hicks, has distinguished himself by the discovery of pre-Cambrian areas in Wales, both north and south, and stimulated by the desire to add to his territory, has recently sought fresh conquests in the Scottish Highlands. His investigations have resulted in a paper read before the Geological Society, in May, 1878, "On the Metamorphic and Overlying Rocks in the neighbourhood of Loch Maree," wherein he gives a section extending from that Loch to Ben Fyn, and endeavours to show that the interpretations of the country previously given are in some important points incorrect.

This section, it will be at once perceived, embraces a much greater stretch of country to the eastward than either of the two (Figs. 10 and 11) previously given. The author, who, like all previous ones, is not a little troubled by the "igneous" rock which is so largely developed in Glen Laggan, adopts with some slight modification the views of Murchison and Geikie as to the Silurian age of the great mass of rock which forms the east side of Glen Laggan. Practically, therefore, he adopts the continuous upward sequence between the Silurian limestones on the west side of the valley, and the flaggy, quartziferous and micaceous series on the east, which forms the base of the Eastern Gneiss of the controversy. The fault, which is shown in the section (Fig. 12) at the point where the eastern "arm of the invading mass" for a short interval separates the subordinate varieties *e* and *f* of the author's Silurian, does not appear to produce any important effect on the general sequence, and is perhaps introduced simply to mark the point

HICKS, 1878.—SECTION FROM THE NORTH SIDE OF LOCH MAREE TO BEN FYN, NEAR AUCHNASHEEN (LOCH ROSHK—LENGTH ABOUT FIFTEEN MILES). Q. J. G. S., Vol. xxxiv., p. 812.



a PRE-CAMBRIAN—Gneiss, hornblende schists, mica-schists, &c.
b CAMBRIAN—Conglomerates, grits, sandstones, shales, &c.
c, c^1, c^2 Sandstones, flaggy beds, quartzites, &c.
* Granite, Syenite, &c. †

d Limestone, calcareous sand-stones, &c. *e* Blue flags, sandstones, &c. *f* Argillaceous, quartziferous and micaceous flaggy beds.

SILURIAN.

† These names scarcely convey an accurate notion of the masses of so-called igneus rock of Glen Laggan, &c. The mineral which characterizes the group is a red felspar, with a hackly fracture, which, in spite of its colour, has more of the character of oligoclase than of orthoclase, though of course this latter occurs. Where not too much granulated, this felspar is observed to be much striated; it contains some lime, much soda, and but little potash. The quartz is usually associated in a gneissoid manner, but not always; and in those cases where some white mica is developed, the rock might almost be called a granite. Strings of epidosite pervade many of the beds, especially in Glen Laggan. On the whole it seems to belong to the granitoidites rather than to the granites, and from its association with other bedded masses, gives the idea of an old gneiss partly invaded by extravasated matter.—W. H. H.

where the great hypothetical fault of Nicol should be drawn.* At any rate, whether the author holds that there is a fault here or not, he does not believe with Nicol that there is any re-appearance of the Fundamental Gneiss at this point, but agrees with Murchison and Geikie that the whole eastern flank of Glen Laggan, on the parallel where the section is drawn, is "a younger series, and that it overlies the unaltered beds." He demurs, however, to the view held by them that the rocks which compose this group, as exhibited here, should be called gneiss rocks, and he still further differs from their conclusions in exhibiting these flaggy, quartziferous and micaceous Silurians as resting uncomformably, throughout the length of Glen Docherty upon a really gneissic and pre-Cambrian Series possessed of a different strike. It is evident that the author has some difficulty in disposing of the eastern ends of his flaggy, quartziferous, and micaceous Silurians since they are represented as disappearing in a somewhat unaccountable manner at the ravine which separates this block of high ground from the range of Ben Fyn. Faults there may be of minor importance, such perhaps as the one indicated in the aforesaid ravine, but on the whole the evidence seems to show that these Silurian beds have been deposited on the eroded edges of the lower gneiss rocks nearly in the positions in which they are now found, due allowance being made for subsequent tilting. Thus their disappearance on the east would seem to be the result of unconformity.

Dr. Hicks, therefore, gets rid of the Silurians at a point considerably to the eastward of where Nicol wished them to disappear, and, although not objecting to the aid of faults on a small scale, refers their disappearance to other causes. He lays considerable stress on the lithological character of the rocks of Ben Fyn, being convinced that the whole of the mountain consists of the lower gneiss rocks—here a highly crystalline series, chiefly gneiss with garnets, mica-schists also with abundance of garnets, and some hornblende-schist. The strike also is more in accordance with that of the Fundamental Gneiss of the west. Coupling these facts with the assumed unconformity noted as running through Glen Docherty, he summarises the results of his experiences in the section (Fig. 12) given above.

These conclusions differ on the whole materially from the latest

* No fault is shown at this point in Dr. Hicks' enlarged section of Glen Laggan. *Vol. cit.*, p. 814.

expression of opinion on the subject of Highland geology as enunciated in the last edition of Geikie's beautiful geological map of Scotland, wherein all this region is represented as Silurian without so much as a break even of "igneous" rock. But we have seen that Murchison was quite prepared to have the Fundamental Gneiss brought up again on the east side of his younger gneiss (Silurian) in certain places and under certain conditions. Without, therefore, calling in the aid of the unconformity invoked by Dr. Hicks, something of the sort anticipated by Murchison may have occurred in the neighbourhood of Ben Fyn, though no such "syenite domes" as Ben Laoghal and Ben Stomino break the crust. On the other hand,* Murchison claims, that where the micaceous series is invaded by granite, as in the country between Assynt and Lairg, alteration produces a gneiss like that of the west coast. If this latter view be correct, a greater proximity to igneous foci themselves invisible may account in part for such appearances as those noted by Dr. Hicks on Ben Fyn, and which seem also to have been noted by Murchison on the neighbouring mountain of Aigean.†

It would be scarcely right to take leave of this subject without briefly noticing some of the petrological questions so intimately associated with the controversy respecting the age of the gneiss rocks of the North West Highlands. Setting aside for the present all stratigraphical evidence, it is clear that there has been, on the part of many people, a strong dislike on *primâ facie* grounds to admit the Silurian age of such a large mass of crystalline rocks. This unwillingness to yield to the conclusions apparently required by the field geologist arises from two principal considerations. 1st. That the Cambrian sandstones and Silurian quartzites and limestones are but little altered in comparison with the Eastern Gneiss which appears to overlie them. 2nd. The prevalence of the idea that no great mass of truly crystalline rocks could be formed at so comparatively recent a period as the Silurian.

The first objection is local in its application, and can only be met by a fuller description of the region in question. It is evident that this objection weighed powerfully with Prof. Nicol, hence his desire to find a fault on all occasions.

The second objection is general in its application, and involves a

* *Vide* supra, p. 62.

† *Vide* supra, p. 62.

most important principle, viz., "that there is no good and sufficie reason for believing in the present existence of any uncrystallin representative of crystalline formations, or of any such formatic which is not pre-Silurian, if not pre-Cambrian, in age." This merely reproducing in modern language, and with greater prec sion, the old views as to the high antiquity of all gneiss rock views so rudely shaken by the publication of Murchison's paper This school finds an able advocate in Dr. Sterry Hunt, who h completely changed his opinions as to the geological age of th presumed crystalline equivalents of the Silurian rocks sin the publication of the articles already quoted.* That auth now considers that in Archæan times there prevailed chemic activities and atmospheric conditions different to what we no experience—as, indeed, was also supposed by Delabeche—that th state of things was not confined merely to a seething primæv ocean, but continued through subsequent ages when detrital matter and even limestone were being deposited. The argillaceous por tions of these detrital matters may have re-acted with thermal water whereby, in combination with other ingredients, insoluble silicate were formed, such as now exist in the various rocks of the crystal line formations. The chemical activities concerned in the pro duction of the various silicates having suffered diminution throug the successive ages of Archæan time, there are recognizable diffe ences, both mineralogical and lithological, in the successive crystal line formations (terranes). Each of these have their quartzite and also their limestones, the latter being associated with serpentin hornblende and mica; so that the presence of this class of rock is no particular test of age. The essential and characteristic diffe ences are to be sought in the alumina-rocks dependant upon decrease in the proportion of alkalies.†

Briefly, then, geologists of this school reject the doctrine metamorphism, or rather of metasomatosis as ordinarily held,‡ an consider that the great groups of crystalline stratified rocks are the re sult of re-arrangement without change of substance from the ancie

* *Vide* supra p. 72.

† 1 (Oldest) orthoclase and albite. 2. Muscovite (potash or biaxial mic damourite (hydrous potash mica), paragonite (hydrous soda mica). Andalusite (SiO_2, 36.8 Al_2O_3, 63.2, the alumina being slightly replaced l ferric oxide), fibrolite, cyanite, and pyrophyllite.

‡ The *diagenesis* of Gümbel, as distinguished from *epigenesis* involvi some change of substance.

aqueous deposits, and that each group has a character by which it may be known and recognised anywhere, just as the fossiliferous systems of subsequent ages are known and recognised by their included organic remains. As before observed, these groups are all pre-Silurian, if not pre-Cambrian, in age, and therefore if any crystalline formation seems to overlie a known fossiliferous system, it becomes necessary to explain this apparent anomaly in some way or other.

It would be superfluous, therefore, to show you how incompatible these doctrines are, if insisted upon in all their integrity, with the conclusions of Murchison and Geikie in regard to this particular district. It is impossible, now says the geological-chemist, that this Eastern Gneiss can be Silurian, there wasn't alkali enough in those days to make a good crystalline rock. But, says the field geologist, this Eastern Gneiss can be seen to overlie rocks with Silurian fossils for more than a hundred miles. How do you explain that? Oh, says the Aberdeen Professor, that's an optical illusion; it's only an old friend in a different attitude. Your Eastern Gneiss is your Western Gneiss, or something very near it, brought up by a fault. Not so, says Dr. Hicks, the Aberdeen Professor is wrong, there is no fault; but Murchison and Geikie are wrong likewise, the Western Gneiss does re-appear on the east, not in consequence of a fault, but owing to an unconformity.

I can well imagine, that by this time most of you are in a "fearful fog" as to the merits of this controversy. I am free to confess that such is my condition at the present moment, hence I have carefully abstained from obtruding any views of my own on the subject, and have simply endeavoured to act the part of an impartial historian. That there is room for further investigation in this vast and interesting district, few of you will doubt, and if any here are disposed to take up the question, they will find a tour in the north-west Highlands none the less agreeable when they can combine the enjoyment of its scenery with the study of its rocks.

ORDINARY MEETING, December 6th, 1879.

Prof. Morris, M.A., F.G.S., President, in the Chair.

The Donations to the Library since the previous meeting were announced.

The following were elected Members of the Association :—

Ernest Bird, Esq.; James Chisledon, Esq.; Miss C. A. Raisin; and Frank Rowbotham, Esq.

The following Papers were read :—

1. On the So-called "Crater Necks" and "Volcanic Bombs" of County Antrim, Ireland.

By W. Mattieu Williams, F.R.A.S., F.C.S.

(Abstract.)

After quoting the descriptions of these on page 68 and page 146 of Mr. Hull's "Physical Geography and Geology of Ireland," and referring to the conclusions of other geologists, the author states that the resemblance of the beach boulders forming the floor of the sea-worn cavern under Dunluce Castle to those at the foot of the sea-worn boulder cliffs of Galway Bay, suggested the possibility of similar origin. The Dnnluce boulders resemble those of Galway Bay in shape and size; those nearest to the sea are rounded, while higher up, where less exposed to wave action, they are sub-angular; but they differ in composition. Carboniferous Limestone is the prevailing material of the Galway boulders, basalt that of the Dunluce boulders, but in both cases a small proportion of the boulders are granitic. A few of the Galway boulders are basaltic, and a similar proportion of the Dunluce boulders appear to be of Carboniferous Limestone.

The cavern walls, which afford an admirable section, display a conglomerate consisting of sub-angular masses of rock of irregular shapes and sizes, and of varying colour and composition, imbedded in a matrix of brick-like material, just such as would be formed by the gradual baking of Boulder Clay or Till.

The author infers that it is actually a deposit of Glacial Drift that has been baked by subsequent volcanic agency; and that the

boulder masses cannot be volcanic bombs that have fallen on the spot, as they are neither of the spherical or spheroidal form of fluid masses consolidated in the air, nor have they any resemblance to the lava bombs so commonly ejected from Vesuvius and other active volcanoes, which are flattened and splashed out on striking the ground. They differ from these not only in shape but also in molecular constitution. All such suddenly cooled lava, whether compact or of porous pumice-like structure, is either vitreous or fibrous. The Dunluce boulders are neither; all that are of volcanic origin being of the same granular basaltic structure as the neighbouring basaltic rocks, indicating similar conditions of formation and cooling.

The theory more recently suggested by Mr. Hull that "we have here, instead of old volcanic necks, simply pipes, formed by the filtration out of the Chalk, into which the basaltic masses have fallen or slipped down," is controverted in this paper on the ground that the imbedded boulders have not the angular character of such *débris*, but are sub-angular in varying degrees, corresponding to glacier boulders.

The author refers to other examples of similar conglomerate which he saw on driving round the Antrim coast, and describes one at Carrack-a-Rede, where the public car stops to afford tourists an opportunity of examining or crossing the rope bridge of the fishermen. Here the whole formation is well displayed, with the advantage of being seen in full daylight. An overlying stream of basalt forms the surface of the precipitous rock-island which is connected with the mainland by the rope bridge. This stream of basalt rests directly upon a base of conglomerate, similar to that of Dunluce.

The visible section is above 80 feet thick. The heterogeneous character of this conglomerate is not so strongly marked as at Dunluce, the boulders and their matrix being so nearly alike in colour and structure, that the true character of the rock may be easily overlooked, as it appears to have been hitherto. This may arise from the close proximity of the basalt, which here coming in direct contact with the supposed clay matrix (itself formed mainly of ice-ground basalt) would heat it to incipient fusion, and thereby render it more like its imbedded basalt boulders than the clay which has been less intensely heated greater distance from the lava flow.

The path leading to the ladder by which the bridge is approach- passses over a deposit of this obscurely defined conglomerate, whi extends over an area far too great to be covered by the hypothe of its deposition in "crater-necks" or "pipes."

Should further observation, and especially the discovery striated boulders in the conglomerate, confirm the above hypothe of its origin, it will show that the volcanic activity to which lavas of the N.E. of Ireland are due, has extended from Miocene to the Post-Glacial or Inter-Glacial Period; or that th have been two or more volcanic epochs, Pre-Glacial and Po Glacial; the early lavas of the first having, by their disintegrati supplied the boulder clay that was baked by the overflowing la of the second.

Such recent extension of a volcanic period in Ireland is accordance with the records of ancient Irish traditions, such the "Annals of the Four Masters," &c. A paper was read before Royal Irish Academy, June 23, 1873, by Dr. Sigerson, and p lished in the Society's Proceedings, in which he has collected so of the best authenticated of these accounts, and has compa them with the descriptions of similar phenomena more recen observed in the volcanic districts of Naples, Sicily, South Ameri Siberia, &c.

As we now know that man existed in Britain during the Int Glacial, if not the Pre-Glacial period, that violent volcanic distur ances do not suddenly subside, and that volcanic regions are lia to renewed outbreaks after long ages of repose like that wh preceded the destruction of Herculaneum and Pompeii, there is inherent improbability in the idea that the termination o secondary period of minor volcanic activity may, in Ireland, h lingered on into continuity with the beginnings of tradition, or ev of the earliest historical records.

2. On the Volcanic Region of Auvergne.

By W. F. Black, F.G.S.Ed.

ORDINARY MEETING, January 3rd, 1879.

Prof. Morris, M.A., F.G.S., President, in the Chair.

The Donations received since the previous Meeting were announced.

The following was elected a Member of the Association:—

Lawrence Scate, Esq.

The following Paper was read:—

On the British Eocenes and their Deposition.

By J. Starkie Gardner, F.G.S.

The Eocenes of England are so familiar to every student of geology that it would appear but little remains to be said about them which has not been said already, as well in a sketchy and popular form as in more scientific treatises. So carefully has their Fauna been worked out, and equally so the corresponding series in France, that it is rare indeed that any new form is added to the lists. Those who are familiar with the best known localities where fossils occur in greatest abundance—on the Hampshire, Isle of Wight, Sussex, and Kentish coasts—know that even the rarer treasures they come across are all known and described.

It is quite otherwise with the Flora, the British literature of which is most meagre. Although plant-remains are in all probability far more abundant and varied than those of animals, and possess in many respects, at the present time, a higher interest, we have to turn to the pages of French, Swiss, Austrian, German, Italian, American, and, indeed, to the works of every civilised country but our own, if we wish to learn anything respecting them. It is useless to enter into the variety of causes which have led to this state of things, but it is primarily due to that habit of caution and thought, and the desire to find a basis of solid fact, which distinguishes so many of the more important works of our countrymen. Hence English botanists have refused to determine plants upon material which is quite insufficient in most cases; and although the result has been that, in this particular line of research, foreigners have quite outstripped us, those who study the subject have cause

to wish that they had themselves been imbued with some of the same spirit.

I propose to describe the British Eocenes, therefore, with especial regard to the floras they contain; and although it takes me over much ground that is not new to you, it is important that I should do so, so that you may become aware of the absolutely certain data upon which the sequence assigned to the *English Eocene Floras* is based, and how definite is their position in the geological scale. Their comparatively exceptional value will then be fully realised. The composition of the various floras we shall scarcely glance at—that is not within the scope of the paper—but I wish especially to lay before you some speculations which have been induced in my mind through their presence, and the examination of them which I have already made. Their exact botanical determinations is work for the future, and Baron von Ettingshausen is engaged upon a preliminary examination of the fruits of Sheppey.

The age of the very localised beds on the continent in which most of the Tertiary and Cretaceous floras have been found, has in almost every instance been ascertained only approximately. The majority of them either lie upon far older rocks, or upon marine beds with which their deposition had no connection. In such cases the data required for the exact determination of their age are wholly wanting, and the ages were inferred from plant evidence alone. This, I am perfectly sure, has not hitherto been entitled to that credence which may become attached to it when more floras, as extensive and well defined in age as that of Oeningen, for example, shall have been described.

Description of Eocene Strata in England.—The gap between the Cretaceous and Eocene formations in Western Europe, upon which I have contributed a paper in the "Popular Science Review" for January 1879, is further increased in England by the absence of the lower members of the Eocene of France and Belgium.*

The Thanet Sands † are almost confined in England to the

* Hébert, "Ann. Soc. Geol.," Vol. iv.

† These are widely spread over Picardy and Flanders as the Sables de Bracheux, and over Belgium as the Landénien inférieur. The three or four feet of sand which fill in the eroded surface of the Chalk, and rest upon the familiar green-coated flints, have been thought to represent the series in Hampshire.—See Prestwich, Q. J. G. S., Vol. viii, p. 237; "Mem. Geol. Surv.," Vol. iv., pt. I., 55; and Hébert, l.c.

eastern area of the London Basin, but with this and one other exception all the Lower and Middle Eocenes are represented at Alum Bay, and in consecutive order. They may, indeed, owing to their vertical position and the height and accessibility of the cliffs, all be studied within a space of a few hundred yards. I think, therefore, it will be most simple to describe each series of beds of the Alum Bay section separately, pointing out at the same time their extent and nature on the mainland. With this object, the principal features of Professor Prestwich's admirable sections both of Alum and Whitecliff Bay are reproduced, although modified to suit the somewhat different interpretation which I have given to them. The section shows that the oldest Eocene deposit present, except perhaps the small patches of sand filling in the erosions in the Chalk, belong to the Woolwich and Reading series.

The equivalents of these in the Hants Basin are compact masses of more or less ferruginous, homogenous mottled clay, unfossiliferous with the single exception of traces of lignite. They are supposed to be of fluviatile origin, and derived from granite. It will be observed that the beds thin out from a thickness of 160 feet at Whitecliff Bay to only 80' at Alum Bay. This thinning continues west, so that at Studland Bay their presence is hardly perceptible. When we trace the corresponding beds from W. to E. within the London Basin, we find—first mottled clays, like those of Hampshire, then beds of lignite and sand containing fresh and brackish water shells mingled with it, and finally that E. of London the mottled clays disappear altogether, their place being taken by sands with estuarine shells.*

I would here parenthetically remark that throughout our Eocenes fresh-water beds are far more developed in the west than in the east, and this holds good even when they are local or on a small scale.

The Oldhaven Beds.—Although these do not occur in this basin they form a well recognised division in the London Basin. They consist wholly of beds of well-rolled flint shingle or fine sand. The fossils are intermediate in character between those of the London Clay and Woolwich and Reading series, a large proportion

* Very similar formations occur in the Paris Basin and in Belgium which are supposed to be of this age. They are known as the *Argile plastique et lignites* and the *Landénien supérieur.*

coming from one or passing into the other; occasionally th
common to all three, and are estuarine and marine. The pr
mass occurs in Kent, and the beds have not been traced in
shire nor on the Continent.

THE LONDON CLAY.—This is represented in the Isle of
principally by compact brown clay with septaria.* Mr Pre
assigns to it at Alum Bay, a thickness of a little less than 2(
placing the division just above No. 6 of his section. I
however, it should be placed as high as No. 14, so as to incl
succeeding 176 feet of marine sands. These so resemble the s
yellow grey sands, with seams of dark grey clay, intercalated a
between two masses of undoubted London Clay, as to be litholc
indistinguishable. Very similar sands are also intercalated b
masses of true London Clay with septaria, at Whitecliff. Th
besides, totally unlike any of the Lower Bagshot Sands in the d
although they have hitherto been included with them, and
marine, while the latter are of fresh-water origin. At Whitecl
307 feet thick. In the London Basin this clay thickens eas
being 50 feet at Newbury, about 400 to 440 feet at London, a
at Sheppey and on the coast opposite. It has been divided into
zones, marking the progressive increase in the depth of th
Towards Harwich it has a considerable N.E. extension, an
traced across the Channel to Calais, and thence to Belgium,
Argille d'Ypres. It never, however, extended over the Pari

THE LOWER BAGSHOT BEDS.—These are well exposed at
Bay, although but 73 feet thick, according to my grouping.†
there consist principally of bright coloured, sometimes m
sharp, quartzose sands, the prevailing colours of which are
yellow and deep red. These enclose here and elsewhere ba
patches of almost pure white pipe-clay, one of which, pres
Alum Bay, has yielded the flora. The beds vary in character
very short distances. For example, there is a thick seam o
red coarse sand near the top of the cliff, and no trace of it
base. Whilst the beds are seen at Studland and round C
thicken very considerably west, they thin rapidly east, and ap

* Although it contains only the shallow-water Mollusca, peculia
London Basin to the lower section of the London Clay, it was
contemporary with its upper section there.

† 249 feet, according to the Geological Survey.

change their character, being, perhaps, represented at Whitecliff Bay by some of the 98 feet of "broad-striped sands, of various shades of yellow, passing upwards into nearly white sand," No. 5 of Prestwich's section. Beds of this age may be distinguished from the overlying strata, if unfossiliferous by the total absence of flint in them, by the brilliant hues or pure white of much of the clays, and by their coarse quartzose sands. They are also traceable over the western area of the London Basin. East of Windsor the fresh-water beds, like the older mottled clays, are replaced by beds entirely made up of rolled flint and shingle derived from the Chalk.*

THE MIDDLE BAGSHOT BEDS.—These, according to the extent which I assign to them, comprise the whole of the Bracklesham, the Bournemouth, and the Bovey Tracey deposit, and the Middle and so-called Upper Bagshot Beds of the London Basin. I have, it will be seen, enriched this portion of the series in a rather wholesale way, throwing into them not only a great part of the so-called Lower and Upper Bagshots, but the only piece of Miocene which we had in England. I have elsewhere stated my views upon these questions,† and time does not permit me to enter into them here. There is no need to describe the Bracklesham Beds. They are partly or entirely the marine equivalents of the Bournemouth and Bovey fresh-water beds, and of the littoral Boscombe and Hengistbury Head beds. They cover a limited area, and are present to but a slight extent in the more S. and W. portions of the London Basin. Their fauna is peculiar to them in England, but extends far over France in the *Calcaire grossier* and other beds. They can, everywhere I believe, be recognised, in the absence of fossils, by the presence of green grains.

The *Bournemouth Beds* are divisible into three, the Lower one fresh-water, the others marine. The fresh-water beds are best represented on the coast from Poole Harbour to Bournemouth, and at Alum Bay by Nos. 19 to 24 of Prestwich's section, or 241 feet of sand and clay, the whole being, in the latter locality, full of

* This period is represented in the Paris area by important beds of sand, rarely fossiliferous, and by beds containing plant remains, known as the *Grès du Soissonais*. In the Belgian area the *Yprésien superiéur* and the *Parisélien* are thought to be of this age.

† Geol. Mag., April, 1879, p. 148. Quart. Journ. Geol. Soc., xxxv., p. 209.

lignite and without distinct fossils. In the Whitecliff Bay sectio their equivalents are probably beds 6, 7, and 8, 123 feet thicl I have, after some difficulty, traced all the other beds separatel across to the mainland. Nos. 19 to 21 in the section, almo unfossiliferous everywhere, and composed of dark laminat clays, occupy the coast on each side of Poole Harbour, a extend far inland, where they are dug into for bricl making. Beds 22 and 23, dull-coloured sands, with white a greyish clays, and beds of hard sandstone, represent the gre mass of fossiliferous strata, from a little east of the rise of t cliffs at Poole Harbour, to beyond Bournemouth. Bed 24, 98 fe thick, composed of dark sands, clays and lignite, represents t Lower Marine series of Boscombe, which extends thence to Hengi bury Head. Beds 25 and 26, sands 147 feet thick, which are far the most brilliantly coloured of the whole series at Alum B and contain only scattered layers of large pebbles, represent t *Boscombe Sands* or white sand and shingle of Boscombe a Hengistbury Head, where the only colours they possess, even at t Head and nearest to Alum Bay, are black, chocolate and white. B 27 of tough, blueish clay, with lignite, 71 feet thick, seems to rep sent the *Hengistbury Head Clay* with ironstone. Bed 28, yello white and ochreous sand, 41 feet thick, agrees very well with the *Hi cliff sands* capping the headland, and which I have traced across the base of Highcliff.* The Bovey Tracey beds resemble exactly, a in every respect, the Bournemouth beds in certain places, exc that the thick beds of lignite are absent. Their flora is so identi not only in species, but in their mode of preservation and gro ing, that were specimens mixed, they could not be re-separat The so-called Upper Bagshot Beds of the London Basin are wl sands which overlie the Middle Bagshot sandy clay with gr grains, just as they do at Boscombe, and are in no way distingui able from these. To connect them with the far younger Up Bagshot Sands, we have to dispense altogether with the Up Bracklesbams and the Barton series, and to unite them wit series they do not resemble generally.

THE UPPER BAGSHOT BEDS.

1. *The Barton Beds.*—These are well-developed at Alum B being 250 feet thick, but are even better represented on the ma

* See Quart. Journ. Geol. Soc., *l.c.*

land where their full thickness, 285 feet, and sequence is seen between Highcliffe and Hordwell. They are supposed to be present in the Whitecliff Bay Section, but in the absence of distinct fossils, it is doubtful whether they extended so far east. The deposit is an extremely local one, and cannot be traced beyond the places mentioned.

2. *The Upper Bagshot Sands.*—At Alum Bay these are pure white glass sands without organic remains, which suddenly succeed the Barton Clay. Their thickness cannot be well ascertained, and has been estimated by Prestwich at 100 feet, and by Bristow at from 140 to 200 feet. At Whitecliff Bay their position is occupied by 202 feet of yellowish sands, in which a few casts of marine bivalve shells have been seen. At Hordwell, on the opposite coast, they enclose clays containing marine shells of Barton species. Sands in the London Basin, which more probably belong to the Middle Bagshot have been correlated with these. Such a sudden succession of sand to clay involves no great physical change as apparent from Godwin Austen's researches in the English Channel. He has shown that the deposition of sand is not by accumulation on one spot, but by outward distribution.* "In great sand-plains at the sea bottom, the particles brought down are drifted on over the horizontal surface, till they reach the edge of that quality of sea-bed; they then fall over the slope, and are beyond the combined action which has moved them along. In the deeper sea sand-beds, * * *, the formation of a single stratum may be continued until the effect of its accumulation * * *, admits of a new bed being formed above it; so that the interval of time between one stratum and another in this zone may be very great." The necessary result of this mode of deposition by addition outwards is, that the sand zone overlaps other sea deposits, and a vertical section of a deep sea channel would often present ooze or mud suddenly succeeded, as we have it in the present instance, by clean sand. Mr. Godwin Austen also points out that, whilst on the English and Irish sides of the Channel, black mud-beds are forming in 90 fathoms, there is an area on the French side of clean siliceous sands, with a continuous extent of surface equal to two-thirds the South of England, which suggests comparisons with the sands of the Bagshot Series.

* Quart. Journ. Geol. Soc., 1849, p. 78, 79.

The Upper Bagshots are represented in France by the Sables Moyens and Grès de Beauchamp, and most probably in Belgium by the Bruxellien and Laekenièn systems. In that case a slightly greater percentage of Bracklesham species existed in the Barton seas over the Belgian area than in England.

The Upper Eocenes

Overlying the Lower and Middle Eocene deposits, is a series of strata of fluvio-marine origin, 560 feet thick, in the Isle of Wight. They have usually been considered Eocene by English writers, but are treated on the Continent as Eocene, Oligocene, and even, in their upper stages, Miocene. This upper series has been so ably described by Edward Forbes, that although 20 years have elapsed, little remains to be added. The Upper Bagshot Marine Sands are succeeded at the west corner of Alum Bay by fresh-water beds, abounding in fossils, known as the *Lower Headon Beds*. The *Middle Headon Beds* are dark sandy clays, with marine or estuarine shells, and the *Upper Headon Beds* are like the Lower, purely fresh-water limestones. It is remarkable that, during the whole of this period, there is a relatively greater development of fresh-water beds in the west of the Island and marine beds in the east. Thus, the Lower and Upper Headon Beds, which are fresh-water, are 85 feet and 67 feet thick at Headon Hill, 44 feet and 31 feet at Whitecliff Bay, whilst the marine Middle Headon is only 30 feet thick at Headon Hill, and 100 feet at Whitecliff. The nature of the beds also differs, and we see that the purely fresh-water conditions required for the formation of this description of limestone, did not during the Headon period extend so far east as Whitecliff Bay. The Headon Series at Hordwell is the only representative of the Upper Eocenes on the main-land. All the other and overlying divisions are strictly confined to the Isle of Wight, and are even there seen to occupy a progressively circumscribed area. The next strata, 100 feet thick, are composed of variegated fluviàtile marls and limestones, and are known as the *Osborne Beds*. The divisions are, however, purely arbitrary, being merely, as is often the case, founded upon the presence or absence of certain species of shells.

The Bembridge Limestone follows, about 25 feet in thickness. At this period the peculiar fresh-water conditions required for the for-

mation of such limestones as those of the Headon Beds had travelled east to Whitecliff Bay, whilst the synchronous limestone of Headon Hill was formed under sub-aërial conditions. *The Bembridge Marls* succeed, 70 feet to 90 feet in thickness. They everywhere indicate fresh-water deposition, except at Whitecliff, were they are partially marine, or, at least, brackish water. In the Bembridge Marls occurs a remarkable bed of bluish septarian stone, strongly resembling the harder insect-bearing limestones of the Purbecks. Although unfossiliferous at Whitecliff Bay, where it is well exposed, it has yielded at Gurnet Bay the series of insect and vegetable remains collected by Mr. J. A'Court Smith. *The Hempstead Beds* close the series, and are the newest beds ascribed to Eocene age in England. Lithologically and palæontologically they cannot be distinctly separated from the under-lying Bembridge Marls. They consist of 150′ of fresh-water marls, capped by 20′ marine beds. In the former occur plant remains.

Attempts have been made by many both in England and abroad, to correlate these fresh-water deposits with those of Western Europe. They can, through their fossil remains, be proved, without much difficulty, to be more or less contemporaneous, but no very exact correlation is possible where beds have been deposited by entirely local agencies.

We learn from M. Hébert's writings that a whole group of Eocenes in France and Belgium below the beds equivalent to our Thanet Sands, and of which we have no record in England, were deposited in an area alternately sea and dry land, subject to much oscillation. In the intervals between these recurring changes of level, deposits were formed, but with each they suffered much denudation, so that only fragments of the beds now remain. The deposits were formed, he supposes, by a gulf opening into the North Sea communicating with the ocean between the Shetland Isles and Norway. This sea may have penetrated over portions of England, and left deposits upon the much eroded Chalk, which denudation subsequently carried away. However this may be, there can be no doubt whatever that the *Thanet Sands*, which possess a shallow-water marine fauna of remarkably temperate aspect, considering their Eocene age, were littoral deposits of the same sea, and mark a period of depression in the London Basin.

The marine deposits of the Eocene in England are of tw tinct origins, one of a *Northern* and the other of a *Southern* To form an idea of the relative position of these two seas, i suffice to suppose that the English and St. George's Cha were dry land in these remote times, and to distinguish respec the seas on each side of the barrier thus formed as *Northern* *Southern*. One would include in its area the Bay of Bisca the other the North Sea. Heer's map of Europe in the Mi time enables us to realise the positions they occupied, and sho that they were then still separated by land.* Not only ar faunas of these two seas very distinct, but the lithol characters of the deposits generally suffice for their identifica

Next in age to the shallow-sea deposits of the Thanet Sa the east of the London Basin are the English mottled clays Western area, of fluviatile origin, which are classed wit WOOLWICH AND READING SERIES. In the direction in which th deposited and thin out, we have the first evidence of the *pr of a great river flowing from W. to E.*, and scouring and drain granitic country. In the estuarine beds with lignites a London, belonging to the same series, we can trace its whilst the marine sands in the east part of the London Basi seen by their Mollusca to have been thrown down by the Nor Sea, into which it flowed.

Among the fluviatile forms met with are *Cyrena*, *Me Melanopsis* and *Cerithium*, indicative of warmth, while the m shells are, according to Prestwich, of a more temperate cli Turning to land evidence, the leaves obtained from Reading submitted to Hooker,† who considered that they probably cated a climate similar to that of England at the present but that analogous forms could also be produced from Indi from other floras. De la Harpe ‡ supposed that they belong a warm, but not a tropical, climate. Although the absence a them of any remains of a decidedly tropical vegetation is no c indication that the climate was temperate, since there are no or other tropical-looking plants in many of the leaf patches Bagshot Beds; yet I am inclined to think, from a considerati

* "Tert. Flora der Schweiz.," Vol. iii.
† Quart. Journ. Geol. Soc., pp. 88 and 163, pl. 4.
‡ Bull. Soc. Vaudoise, V., p. 123.

those obtained at Newhaven as well, that the climate was as temperate at least, as the Mediterranean flora of the present day.

It is very singular that we are able to trace throughout the whole Eocene time the presence of this great River, which receded and advanced, and changed the direction of its outfall in obedience to the continued oscillations which this part of its course experienced; and we cannot help noticing how frequently marine conditions predominate in our eastern area, fresh-water in the western.

The next movement at the close of the Woolwich and Reading Beds was probably one of slight upheaval, during which the south-east of England became land. Depression followed, and the Northern Sea gradually reoccupied the tract. The masses of shingle and sand banks of the OLDHAVEN BEDS mark this change and are the result of the littoral conditions which prevailed during the recession, but rearranged and also greatly added to by the next advance of the sea. The remarkable extent to which the flints are worn shows that the duration of these conditions was very considerable, whilst the change in the fauna seems also to indicate a great lapse of time between these events. In some places rolled pebbles of the Mottled Clay are included.

In the LONDON CLAY we see a further considerable depression of the land, enabling the Northern Sea to encroach gradually from the north-east, and ultimately, once only to reach as far west as the present borders of Dorsetshire. From palæontological evidence it appears never to have attained more than a few fathoms in depth in the western area,* and a little more than 100 fathoms in the deeper eastern parts. Throughout its deposition the subsidence of the sea bed must have been quiet and gradual. The marine fauna, although still seen by comparison with those of succeeding beds to be relatively temperate-looking and to belong to the *Northern Sea*,† has a far more torrid aspect. This is owing to a warmer period having

* In the Bognor Beds at Alum Bay deep-sea Mollusca are absent, while their most characteristic and widely-spread genera form a group indicating marine waters of very moderate and tolerably uniform depth (*e.g.* Pinna, Vermetus, Calyptræa, Panopœa, Pholadomya, Turritella, etc.). These beds in the Hants basin were deposited in a shallow and open sea, not often attaining a depth of 30 to 40 feet, and averaging more probably 10 to 20. Prestwich, "Quarterly Journal, Geol. Society," 1846, p. 237.

† Although the abundance of Nautilus seems at first sight to contradict this, it is not unreasonable to suppose that extinct species may have existed

set in, produced probably by the rise of land between England and North America which, there is evidence to show, took place about this time, and completely shut off the cold Arctic currents. The temperature of the sea thus increased, doubtless acted upon the land, and enabled a tropical and most luxuriant and varied fauna and flora to migrate thither and become established. Myriads of fruits and seeds, and the bones of many species of turtle and crocodile, whose habits would cause them to be buried in such a position, as well as of snakes, birds, etc., are found at Sheppey, just as they were stranded and buried in the delta-mud of the great Western River.

This sea had a considerable extension N.E., but none S., whilst the land probably stretched into warm latitudes. The London Clay marine fauna is strongly contrasted with that of the immediately succeeding fauna of the *Southern Sea*, by the abundance of cephalopods and the absence of corals, whilst few species of Mollusca are common to them. Prestwich inferred that this sea was extensive from the width and depth of the London Clay, "which, with a maximum thickness of 480 feet, exhibits a transverse section of 200* miles, conditions which could hardly have obtained without a large river, and, therefore, a large adjacent tract of dry land," the large quantity of organic remains derived from the land indicating the proximity of a tidal river." The estuary of the river was at Sheppey and extended to Woolwich, Upnor, Boughton, where brackish conditions are "evidenced by the great and sudden abundance of Melania and the several species of Cyrena." Its powerful fluviatile action "swept down into this Eocene sea the vast argillaceous sediment, with its rich stores of land plants and marine animals forming the London Clay."

The depression of the S.W. of the London Basin which brought in the sea, was succeeded by a slight elevation in the same direction, which caused it gradually to recede. As the water shallowed, the clay deposited became more and more sandy, and at the top of the London Clay we find sand or loam. The thick beds of sand at Alum Bay, which overlie the Clay, and form part of the series,

in somewhat more temperate waters than the two surviving species. When their presence in any formation appears to necessitate a sea temperature different in degree to that required by all the rest of the Mollusca as a group, the conclusion becomes a natural one.

* Prest., "Quart. Journ. Geol. Soc.," Vol. vi, 279.

may represent a very great lapse of time, for it is well known that a very considerable break may occur in a series of loose sandy strata, and yet there may be no physical evidence of the fact.* Instances of this may be observed in the Bournemouth cliffs and sections wherever they are capped by Drift.

The River, whose delta was hitherto in the eastern area of the London Basin, seems next, owing to a depression to the south, to have shifted its course in that direction. Its mouth, therefore, may, during the succeeding period, have been on the since denuded Wealden Area, or still further off in the present English Channel, and we have no trace of its actual position, until it was still further deflected to the S.W. by the subsidence which later permitted the inroad of the Bracklesham Sea.

The LOWER BAGSHOTS, such as we have them at Alum Bay, Studland, Corfe, etc., were formed by river action, in a wide valley and shallow lake, and show no proximity to the sea. The complexity of the stratification suggests that two rivers united in this valley, and shows plainly that the waters must in any case have been rapid at times, and subject to periodical fluctuations of volume. We see by the composition of the Western fresh-water beds, that a granite area was still being worn away, as in the older *Woolwich and Reading Beds.*

As there are no passage-beds or signs of any delta having existed here between the London Clay and Lower Bagshots, it may be concluded that the river did not immediately occupy this part of the land left dry by the retreat of the London Clay sea, but flowed over it, perhaps long subsequently, having gradually shifted its outfall from E. to S. and W. The great deposits of rolled flints above the London Clay in the eastern parts of the London Basin, show that the *Northern Sea*, littoral at this period, again occupied that area for an immense length of time.

We gather from the absence of lignites in some parts of the series that there were, in the upper parts of the river, lakes such as those of Bovey Tracey, to be presently alluded to, which intercepted drifting timber; its abundance in other beds marking

* Example:—In a railway section at Clermont the Lower Tertiary sands and pebbles are overlaid by drift sands and pebbles. There is an apparent *liaison* between the oldest Tertiary beds and the bed of diluvial pebbles and the sandy alluvium which covers the whole.—D'Archiac, "Bull. Soc. Géol. de France," 2me sér. vol. ii., p. 341.

the time when these had been filled in. The total absence of flint shows that the western Chalk-hills were not yet raised into position for denudation.

Heer, a long while ago, pointed out that the flora contained in the Lower Bagshots of Alum Bay formed a similar group to that of the London Clay.*

In the BOURNEMOUTH BEDS we have deposits of the same river, but in a more open and level valley, and in closer proximity to the sea. In all the lower or freshwater series we have no sign of the presence of sea-water, and when we do find it in the higher beds to the east, it is not that the river deposits encroached there on the sea, but that the land gradually sank, and allowed the sea to cover them.

It is of great interest to trace through these beds the change from a comparatively upland flora, to a valley, and then to a swamp flora; to follow out the lowering of the land until it became sea; to trace the sea, first trickling in as it were, and forming lagoons, then overwhelming the mud deposits formed by these lagoons, with shingle and sand; to realise in fact the actual shore line, now marked by river deposits full of plant remains on one side and a sea fauna with shark's teeth on the other.

The series of *marine beds* from Bournemouth to Highcliff, which belong to the Bracklesham beds, are the shore deposits of the *Southern sea*. The BRACKLESHAM SERIES proper show a gradually deepening sea; for, while the beds of sand which are prevalent in the lower stages show shallow water, the clay beds above them were formed in a deeper sea, and contain deeper water Mollusca. In comparing the marine fauna with that of the London Clay, its very much more tropical character is apparent. Many southern types of Mollusca abound in it which are scarcely represented in the London Clay. Their aspect is completely different, and though separated geologically by but a short interval of time, hardly any species are common to both, while the lithological characters of the formation are widely and persistently dissimilar. If we examine, on the other hand, the terrestrial fauna and flora of these and the intervening strata, we see that no increase of temperature or change had taken place in the climate, and that the land was still inhabited

* "Flor. Tert. Helv.," iii., p. 314.

by similar groups of reptiles and plants. It is therefore plain that the sea alone had changed, and become much warmer, for depression had enabled the *Southern Sea*, then occupying part of France, to advance and to overlap to a small extent the older deposits. The same depression diverted the embouchure of the river towards this area, and its influence is discernible in the Bracklesham Beds, whose shallow sea bottom was subject to drifting water. The Rev. O. Fisher,* remarking upon these facts, says: "The shells in such beds are often drifted into patches, while a few yards off scarcely a specimen will be found;" and, again, that "many of the beds are laminated, being composed of alternations of very thin bands of clay, separated by sandy layers. Such are generally devoid of shells, but contain much vegetable matter. They appear to have been caused by the deposit of sediment, in a quiet estuary from a great river, the changes to the coarser sediment being caused by the state of the flood."

During the whole Eocene period till the time of the deposition of these beds, the now separate Tertiary basins of London and Hampshire were continuous, and similar series of strata were deposited over them. Thenceforth, however, it is clear from the absence of any of the newer Eocene deposits in the former, that they had in some measure become severed. The London Basin must have been upheaved at the close of the Middle Bagshot period, and we have no evidence that it was again depressed, although it has since been subjected to denudation on a large scale.† The depression which lasted throughout the Bracklesham period was prolonged into that of the Barton Beds, which are found to indicate still deeper seas. A remarkable change in the fauna almost suddenly took place. We see an influx of Mollusca of a comparatively temperate aspect, recalling strongly those of the London Clay, many of the species which had disappeared in the intermediate Brackleshams, reappearing in the Barton series.‡ At the same time there was a migration of the more tropical of the Bracklesham

* "Quart. Journ. Geol. Society," 1861, p. 67.

† It has been estimated that the "vertical loss in the Valley of the Thames is 500′," and that "the flat arch of the Isle of Thanet is not wholly owing to the Chalk having been thrown into that form, as at least 600ft. of other formations have been denuded off that tract."—"Memoir of the Geol. Survey," Vol. iii., p. 55.

‡ See Prestwich, "Quart. Journ. Geol. Society," Vol. xiii., p. 131.

forms, including all the larger cones, cowries, bullæ, cerithia, the great cardia and nummulites, only 25 of the least tropical looking Mollusca remaining to mix with the new fauna. This can only be explained by the mingling of the waters of the *Northern and Southern seas*, due to the temporary submergence or destruction of the dividing isthmus, which we know had already become extremely narrow, since deposits of the older seas actually overlapped each other in the Isle of Wight. The succeeding UPPER BAGSHOT SANDS belong to the same period, and, as already remarked, do not necessarily indicate change.

After this the seas were again severed, and remained so until recent times; the English Channel, there is reason to believe, having been indeed formed during the human period.

The whole of the vast overlying fluvio-marine UPPER EOCENE, or Oligocene series, more than 500ft. thick, presents us with the section of a great river delta formed in an area of depression, similar perhaps, to that of the Nile, or Ganges. Each successive estuarine deposit seems to have been thrown down over a more and more circumscribed area, and by a diminishing volume of water. The lowest, or *Headon Beds*, alone can be traced across to the main land; whilst the highest, *Hempstead Beds*, are almost confined to a single hill. These enormous accumulations present us with the record of an unbroken series of events in one spot; extending from the Middle Eocene to perhaps the Miocene age in Europe. During this lapse of time we see constant changes and modifications taking place in the Mollusca. Over and over again fresh species of Cerithiadæ, Linnæidæ, Melaniadæ, and other estuarine shells come in and disappear again. The muddy flats swarmed with these Mollusca, and the banks seem to have been clothed with ferns, reeds and palms. Mammalian remains abound in places throughout the whole series, but even more numerous are those of turtle, gavial, alligator, and crocodile. In the Bembridge Limestone capping Headon Hill, we have an actual subaërial formation, remarkable for the immense number of shells and eggs of large tropical pulmonate Mollusca which it contains, implying an extensive and adjacent land flora. During this period, too, we not only have evidence of the diminution of the volume of the river and final silting up of the estuary, but also of a gradual lowering of the temperature; and, consequently, a more and more wide

departure from the tropical conditions which prevailed during the Middle Eocene, and extended to the close of the Headon period. At last the diminished river, in the cooler Hempstead times, left the country swampy, and covered with rush and water plants.

From the close of the Hempstead period until the river finally became lost, its delta or embouchure may probably have lain in the Solent Channel or in the sea beyond, as there is now no trace of it existing.

The truly marine Mollusca of the highest Hempstead bed appear so impoverished and present such a paucity of species, and these so stunted, that, coupled with the nature and limited area of the deposit, we must conclude that they were formed in a sea which had shrunk to a mere salt or brackish lake, without communication with the open sea beyond. That it was completely isolated is certain, since there is no incoming of the Miocene marine forms which existed abundantly elsewhere. The forms are characteristically Eocene, but, except such as the *Corbula*, which were apparently enabled to withstand the influx of fresh water, of a degraded type. We have no evidence of the Hampshire Basin again becoming submerged; and, although there are abundant indications of larger rivers than those at present existing having flowed through the district even in human times, how far, or whether they were in any way connected with the great waters whose history I have endeavoured to trace, is very doubtful. Nor have the oscillations which produced these frequent changes of level, and at a later period upheaved the Chalk, altogether ceased, as there is abundant evidence in the Isle of Wight, and on adjacent coasts, of elevation and subsidence even in Historic times.

It is interesting to find that Mr. Sorby, now President of the Geological Society, inferred on totally independent grounds—the study of evidence of wave and ripple action in the marine and estuarine beds of the Isle of Wight—that a great river ran from the west into the sea, its estuary including part or the whole of the present Isle of Wight, and that the breadth of its estuary was there 15 or 20 miles. "Yet the dimensions of the river were such as to keep the water in general more or less fresh, and must have been much greater than any now running in England." He was able to trace the approximate size and direction of the shoals, and

the axis for the rise and fall of the tides, the direction of the fresh-water currents and prevailing winds, at least those which acted with most force upon the sea. This confirmation is of value.

Thus, throughout the whole of our Eocenes, the river action may be more or less distinctly traced, and whether we examine the structure of the rocks themselves or the fossils they contain, the conclusion is irresistibly forced upon us that, for countless ages, the mouth of a great river occupied at first the south-east and then the south of what is now England, and that, during the whole period its delta was subject to change of level, becoming more or less depressed, according to the almost universal law wherever great sediments accumulate, as we see in recent deltas, permitting now the sea to invade it, now the deposits to rise above water, and become inhabited by plants and animals.

It is impossible, except by its deposits, to track the course of the river, which, for countless ages, brought down and imbedded plant remains from a western land. The upheaval of the great Chalk ridge and denudation have probably completely obliterated every trace of its former valley, which may moreover have lain where now is sea. At Bovey Tracey, however, there is what appears to be an exceedingly interesting relic, marking the site of what was perhaps formerly a lake, into which it flowed in its course. This is a great basin, of what has been hitherto supposed a perfectly isolated Miocene deposit. I have ascertained, however, on palæontological evidence, that the series is contemporaneous with the Eocene at Bournemouth. This lake, which we see silted up, lies in the direction whence the river came, and must either have been in its direct course or in that of one of its affluents.*

It is not improbable that remains of other lakes may yet be

* Lyell's account of the imbedding of plant-remains in the Slave Lake, is curiously like what must have happened here :—"In Slave Lake in particular, which is 200 m. long, the quantity of drift timber brought down annually is enormous." The trees become water-logged and sink, and "the trunks gradually decay, until they are converted into a blackish-brown substance resembling peat, but which still retains, more or less, of the fibrous structure of the wood; and layers of this often alternate with layers of clay and sand." The banks have "a remarkable horizontal slatey structure" (along the Mackenzie), and display almost everywhere horizontal beds of woody coal, alternating with bituminous clay, gravel, sand, and friable sandstone. * * * The Slave Lake itself must, in process of time, be filled up by the matters daily conveyed into it by the Slave River."—"Principles of Geology," 10th edit., 1868, vol. ii., p. 526.

found in Cornish or Devon valleys. These very lakes may, as already mentioned, by intercepting the drifting timber, have caused the otherwise curious absence of lignite in most of the Bournemouth beds, whilst its abundance in later beds may furnish a clue as to the time at which they became completely filled in.

Having traced the probable existence, for countless ages, of a river of far greater magnitude than any which the drainage of our present England could furnish, and coming from the west, the question arises as to what could have been the extent and position of the land-surface from which it flowed.

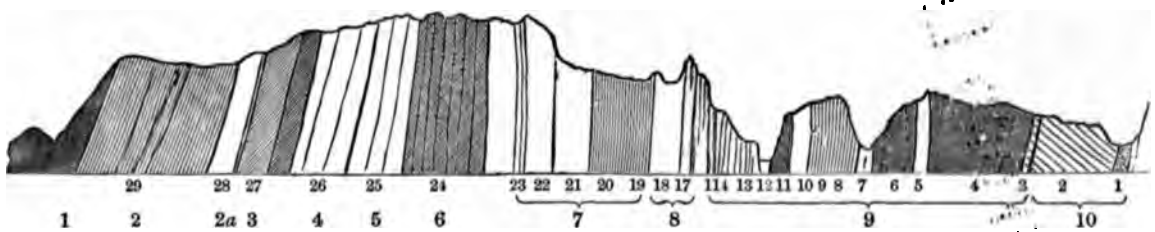
In the first place it is certain that the beds were not deposited under Archipelagic conditions, like those under which it is supposed the Miocene Beds of Central Europe were formed, for great rivers are not found in Archipelagos. Again, independently of the physical evidence of the volume of the river, the plant-remains already known indicate the former existence of floras so large and varied that we cannot but believe that the land-surface upon which they grew, must have been of Continental dimensions.

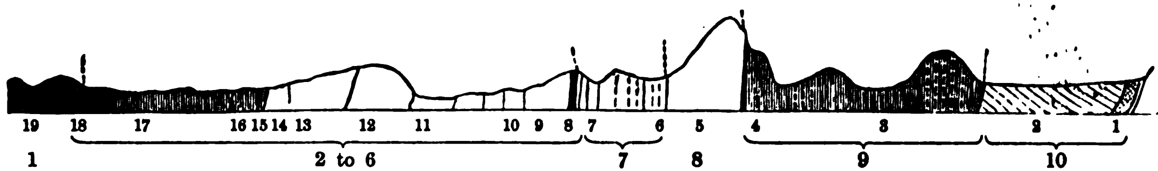
Most of us are probably familiar already with speculations as to the former existence in the Atlantic of a Continental area. One of the earliest of these was in 1847, and due to Edward Forbes. The small Iberian flora lingering in the S.W. of Ireland, was thought to indicate direct preglacial connection with the Spanish Peninsula. He was thence led to think it possible that land might have extended into the Atlantic to beyond the Azores, and that its coast-line was perhaps indicated by the gulf-weed bank between 45° and 15° N. lat. This idea has, however, not met with support, and there are other ways of accounting for its presence. Unger* having identified fossil plants from Sotzka with Australian types, delivered in 1860, a lecture upon the "Sunken Island of Atlantis," and in the following year another entitled "New Holland in Europe." The extraordinary occurrence of American, Asiatic, Australian and African genera in all European Tertiary floras, convinced Heer as well as many others, that some communication had existed between these several lands at former times. The question has since then been frequently discussed from different points of view, as often as fresh discoveries and information have been brought to bear. For a long while all this was but specula-

* Translated in the "Journal of Botany," for January and February, 1865.

Reduced copies of Prof. Prestwich's Sections of the vertical section in Alum and Whitecliff Bays.—From "Quarterly Journal of the Geological Society," 1879, *p.* 226. *Reprinted by permission of the Society.*

SECTION AT ALUM BAY.





SECTION AT WHITECLIFF BAY.

The small numbers used are according to Prestwich, the larger numbers accord with my new nomenclature. The dotted lines indicate the correlation of the beds. The large numbers correspond with those used in fig. 2. 1. The Barton Beds. 2. The Upper Bracklesham and Highcliff Sand. 3. The Hengistbury-Head beds with ironstone. 4. The Hengistbury-Head [illegible] Sands. 6. The Bournemouth Marine series. 7. The Bournemouth Freshwater [illegible] Reading Series.

tion, yet year by year those who have studied the present distribution of genera and species, whether of plants or animals, marine and terrestrial, have become convinced that in times often not geographically remote, continents and islands now separated by seas were united together. The studies of geologists, especially of those working in the Tertiary rocks, show even more conclusively the former connection of lands now widely severed. That a different distribution of land and water prevailed, at all events in Eocene times, in our area, is no longer theory but fact, and in order to account for the leading observed facts, we have to conclude that at various times our Eocene land was connected more or less directly with very distant parts of the world indeed.

It was not, however, until the return of the Challenger Expedition, and the publication of the contour chart of the great Atlantic ridges that it was seen in which lines they were possibly actually connected. This map shows that a great ridge, less than 1,000 fathoms deep, runs in a ziz-zag direction, north and south, sending off spurs which connect N. and S. America with Africa and Britain, or W. Europe. This faintly shadowed sunken continent, supposing it for a moment to have once been land, is so unlike any existing land, that no one would, perhaps, have ventured to evolve so strange a shape to meet the requirements of a theory, yet it is hardly possible that any other form would have sufficed so completely to render possible the union in the Eocene of faunas and floras from so many lands. In a lecture delivered last year at the South Kensington Museum, Mr. W. S. Mitchell very clearly pointed out the bearing that the discovery of this ridge had upon past and present plant distribution.* The main ridge still rises in four places to dry land, and soundings by the U.S.S. "Gettysburg" tend to show that Madeira also was a portion of it. From the deeper basin land also rises at Fernando de Noronha, Trinidad, and St. Helena.

Now, if we consider that since the sinking of the Eocene land many of the great mountain ranges of the world have been upheaved to the colossal heights which they now attain, we may fairly assume that compensating depression had taken place in other areas to an equal extent during the same time. We might thus claim that the

* See "Nature," April 20, 1877.

greatest depths of the Atlantic had been dry valleys and lake-basins, with a mountain chain between them 16,000 feet in elevation, with peaks, such as Ascension and St. Paul, towering to 30,000 feet, forming a vast chain of mountains above the snow level, and stretching from an Austral land across the Equator. But a far less elevation will suffice to explain all yet seen, and the great depths may have remained ocean ever since the Chalk period, and, perhaps, for long before. An elevation of 2,000 fathoms would produce the continent, whose outline we see traced, possessing a ridge 6,000 feet high, rising here and there to 12,000, and this, or even less, would have permitted all the temperate forms we have in the Eocene to have passed right across the Equator. An elevation of less than 1,000 fathoms would unite England and Ireland, and extend the land far west, 600 miles beyond Cornwall, producing an area sufficient to account for the magnitude of the river. I would limit the supposed elevation to the minimum that will explain the facts, because there are no oceanic Eocene deposits known, although vast strata, similar in extent to the Chalk, must have been then, and are now, uninterruptedly forming. It may be supposed these have been brought to the surface and again have sank, for it is certain that areas of sea, contiguous to both Europe and America have been land at no distant date, and the present zoological and botanical distributions make it almost equally certain that great tracts of the bed of the Atlantic were also land.

There is no need, however, to suppose that the whole of the connecting ridges were above water at the same time, or even that the Southern and Northern areas were ever actually connected by unbroken land. The ridge may have been severed from the most southern lands, for example, in the remoter Cretaceous times, and submergence, commenced in the south, have progressed gradually north, giving rise to elevation in front of it, upon which the plants imperceptibly travelled. However the Australian plants, for instance, crossed the Equator, whether by way of Asia, Africa, or the Atlantic, it seems that the bridge behind them became submerged, since the indigenous Australian flora and fauna remain almost unmixed in their original habitats. It is curious that the types derived from this particular flora never reached America, and must very early have ceased to exist in Europe, since scarcely any remnant exists in our present flora.

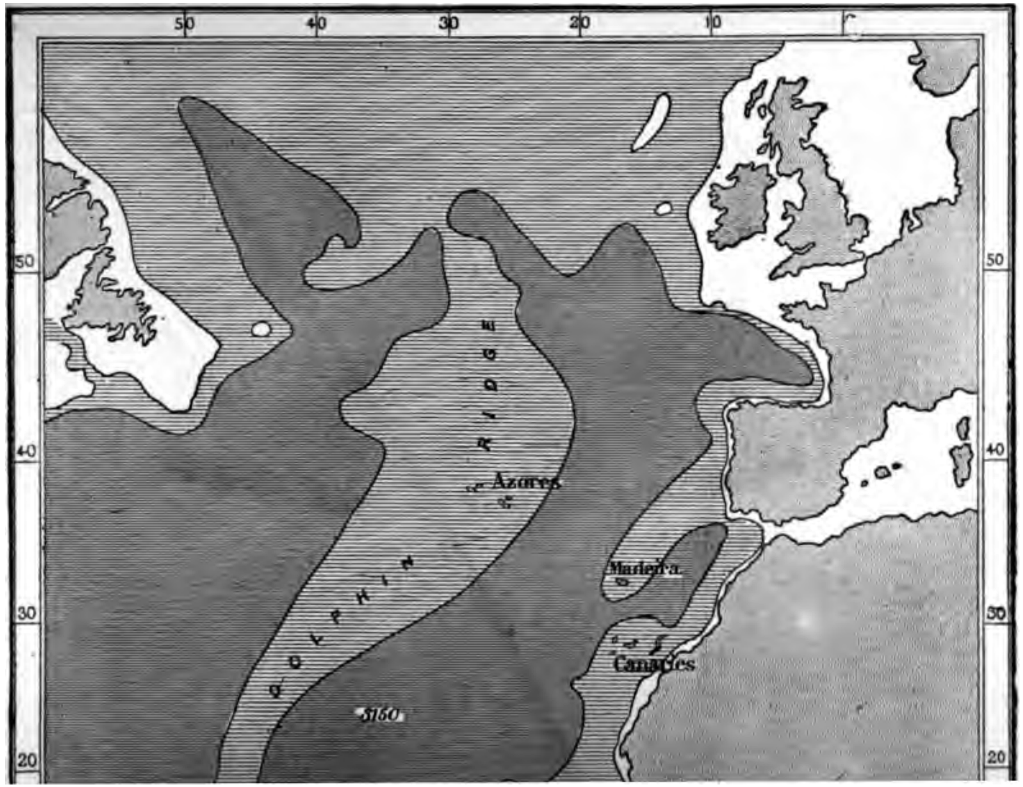
The incoming of American types appears to take another instance, of later date than that of the Australian. In America an almost unbroken record of the land vegetation exists from Cretaceous to Miocene, or even Pliocene times. The lower portion of this sequence is supposed to be older Cretaceous, and although the evidence of such great antiquity is not conclusive, yet it is much older, at all events, than any of the Eocenes. It contains a flora, differing essentially from any other known flora, and which was evidently a completely isolated one. Although principally composd of dicotyledons, and, therefore, eminently Tertiary, it is associated with Dinosaurians,and a fauna largely composed of Cretaceous types. This older flora is rather suddenly replaced by an Eocene flora of European type, including palms and other plants, which appear not to have previously existed in this part of America. The rise of temperature, simultaneously with the incoming of a fauna and flora, in part at least European, taken together with an obvious rise in temperature between the Thanet Sand and the London Clay, and the subsequent appearance in the Bournemouth, or Middle Bagshot, of a preponderance of American plants, seems to fix conclusively the date as *Eocene*, of that rise of land to the North, which united Europe and America, and permitted the floral types to mingle. This connection alone, by shutting off the Arctic currents, would have converted the North Atlantic into an ocean, locked in by land W., N. and E., bounded on the South by the heat of the Equator and in great part under the rays of a tropical sun. These conditions are calculated to produce the hottest climate in the world.

It is probable that throughout the whole of the Eocene period this land was slowly sinking. The great submergence, however, did not take place until Miocene times, and its enormous mass must have at least helped to cause the elevation of the Alps. The magnitude of the subsidence may be inferred from the mass of the elevation. While the London Clay was forming, Lyell points out, the sea still rolled over some of the loftiest summits of the Alps, and the changes that have subsequently occurred equal in amount the conversion of sea into a continent as large and lofty as that of Asia, Europe, and North Africa, and of land into sea to at least an equal extent. "The grand sinking down of the conglomerate of the Molasse, more than a mile vertically,

did not begin till all the Eocene movements had terminated, and the upheaval of the same Molasse took place at a later period, so that it reached at length its present altitude of 3,000 or 4,000 feet above the sea."* In face of such stupendous movements, the oscillations in England were insignificant, the total sum of the depression here in Eocene times not exceeding 1,800 feet. Our area was but the border land, the axis between elevation to the east and subsidence to the west, and although continually shaken, participated decidedly in neither movement. Results of the forces which acted are to be seen in the vertical beds, and the contorted strata on our south-western coasts around the Isle of Wight, for the general direction from South to North of the folds of the Chalk is evidently the result of lateral pressure, and not the direct action of local forces.

My work has led me to the belief that throughout the whole Eocene Period a vast river flowed from the westward, from an area now so reduced in size that it would now support but comparatively small streams. The discovery of the abundance and variety of the flora brought down by it, together with the evidence we possess from the difference of the fauna of the Eocene seas in portions of their basins now dry land, that at that time the North Sea and the Bay of Biscay were as completely severed as the Atlantic and Pacific, and tend to confirm theories leading in the same direction, put forward formerly by many and independent workers.

* Lyell. "Anniversary Address" to the Geological Society, 1850.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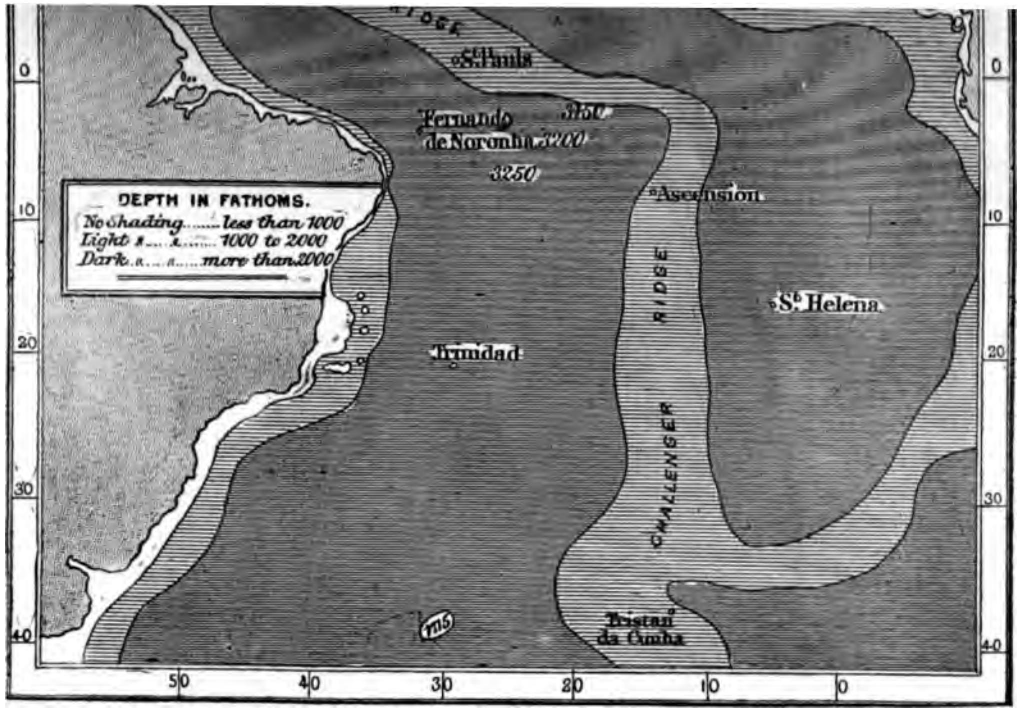

CHART OF ATLANTIC SOUNDINGS.

ANNUAL GENERAL MEETING, February 7th, 1879.

Prof. Morris, M.A., F.G.S., President, in the Chair.

The Honorary Secretary read the following :—

Report of the General Committee for the Year 1878.

Your Committee regret to say that during the past year the number of new Members elected was very much below that of the previous one. Thus—

Members elected during 1878 . . .		32
Deaths	9	
Withdrawals	13	
Exclusions	5—	27
Increase		5

The Members elected during 1877 numbered 49, as against 32 during 1878, but this falling off, great though it be, is not more than what has occurred in other societies. Thus the Geological Society during 1877 elected 76 new members, and during 1878 only 53 ; and for the Quekett Microscopical Club the corresponding numbers were 65 and 45. We must, therefore, look to some general cause for the explanation of the falling off in new Members during last year, and the probability is that the Learned Societies are feeling the effects of that wave of depression from which so many interests have been and still are suffering.

The following is a list of the Members who have died during last year :—

Mr. Thos. Belt, F.G.S.
" M. L. Bujac.
" G. Guyon, F.R.M.S., &c.
" J. Harper, F.G.S.
" H. Letts.
Mr. J. Rofe, F.G.S.
" W. A. Shields.
" J. Sterriker.
" A. Thompson.

Mr. Thos. Belt was the author of a very interesting work on Nicaragua. He was also well known as a mining engineer and a

geologist, principally in connection with the phenomena of the Glacial Period. The theory which he so strongly advocated of accounting for these phenomena by variations in the inclination of the earth's axis was specially commented on by Dr. Henry Woodward in his Presidential Address to the Association in 1873.

Though the receipts from entrance fees and subscriptions are less this year than last, the finances of the Association continue in a satisfactory condition, as the balance-sheet appended to this report shows.

"The formation of a Library," or "the gathering of sound geological books," for the purpose of reference and study, was one of the "objects" for which the Geologists' Association was established, and one which was immediately acted on, for at the second Ordinary Meeting (March 8, 1859) this useful undertaking was fairly started, the first donations being recorded in the Proceedings of the evening.

Since that date, with some few exceptions at the beginning, donations have continued to come in at each meeting in steady, but ever-increasing numbers.

Voluntary contributions formed for some time the sole support of the infant Library, till at the Annual Meeting, held January 7, 1861, the Committee were enabled to recommend that the sum of £5 should be expended in the purchase of "good geological works." The report being adopted, this recommendation was carried into effect, and a list of the works thus obtained is appended to the proceedings of that date. Further sums were afterwards, from time to time, invested in like manner, notably in 1862, when the still unrivalled "Memoirs of the Palæontographical Society" were added to the collection.

A third source, whence additions to the Library are obtained, has been by exchanging "Proceedings" with kindred Societies all over the country. A series of useful and valuable volumes have thus been gathered together at a small expense to the Association, but to the greatly enhanced worth of the Library, both as a means of reference and of acquainting Members with the work of various local geologists who contribute the results of their investigations to such Societies.

Starting with only ten, this practice has gradually spread, till

last year there were more than thirty societies on the list, to which several more have lately been added, and amongst them the "Société Géologique de France."

Thus, in one way and another, has the Library assumed such proportions, that it was felt the Catalogue need no longer appear as an Appendix to the Annual Report, but might fairly be printed as a separate publication.

Some delay unavoidably occurred in the accomplishment of this resolve; for a new Catalogue implied the entire revision of the whole collection.

It was necessary to re-arrange the volumes, adopting such a system as would permit of any given work being readily found when wanted; to catalogue the different works more fully than had been hitherto requisite; and to introduce other slight changes, which, it is hoped, will enable Members to obtain the books they require with greater facility than heretofore.

Your Committee, however, are at length able to report the accomplishment of this object, and trust that the Catalogue now in the hands of Members may meet with their approbation, and prove of practical value to them.

A large number of volumes, some of them of great value, have lately been bound, and so made available for circulation. Many of these volumes are the Journals or Transactions of the various Societies with whom we exchange "Proceedings," and to whom application had been made for missing numbers. In the majority of cases this application was most kindly responded to, including two instances in which previous to that date no exchange had been organised.

During the past year a great many donations have been received, and your Committee trust that, now the Catalogue is published and the exact wants of the Library fully known, Members may be thereby induced to contribute any duplicate tracts or books they may possess to the common stock, so that fellow Members may have the benefit of their use, and the value of the Library be further enhanced.

Owing to the large expenditure incurred by the binding and purchase of books, and in printing the Catalogue, your Committee trust that very little need be spent on the Library for some time to come.

The attention of members is drawn to the "Library Regulations," a copy of which will be found inside the cover of each volume, as the well-being and usefulness of the Library in a great measure depend on their due observance.

The Committee offer, on your behalf, the thanks of the Association to Mr. E. Litchfield for the kind way in which he has for some years past assisted its successive Librarians in the discharge of their pressing duties on meeting nights.

There have been, as usual, many interesting demonstrations on subjects of geological interest during the past year.

Dr. Günther, at the British Museum, exhibited specimens of the recent dipnous fishes, Ceratodus and Lepidosiren, explaining the peculiarities of their anatomical structure; after which Professor Morris gave a lecture on the allied fossil forms in the cases of the Museum.

Mr. Carruthers, also at the British Museum, gave a lecture on the Vegetable Kingdom from the rich collection of dried plants in the Museum, showing the affinities between many existing plants and their fossil allies.

At the Crystal Palace the President explained many geological specimens and well-constructed models of geological interest in the building and grounds.

At the Zoological Gardens, to a very large meeting of the Members, to whom a free pass was given, Dr. Sclater gave short demonstrations at the dens of several of the most interesting species of animals, explaining their life-history and the fossil forms allied to them.

At Boulogne, under the able guidance of the French Directors of that Excursion, the Members had an opportunity of examining a collection of the fossils of the district in the Museum of Natural History of that town.

The Excursions have, as usual, been well attended during the past year, and we have again to thank our Directors for the able manner in which they have pointed out to Members the most interesting geological features of the localities visited, and for the trouble they have taken in arranging the many details necessary to their success. It was a new feature in the Excursions of the Association to extend their range to a foreign country, but the success

which attended the Long Excursion to the Boulonnais last August may lead to its being repeated at some future time.

We are so much in the habit in our own country of having the most able geologists as our Directors that we might well have been disappointed in endeavouring to conduct one on the Continent, but the most numerously attended of any long-excursion of the Association can testify to the able and courteous leadership of the eminent French Geologists who were our Directors on that occasion—some of whom came from a distance for that purpose—and of the great geological interest of the locality visited.

Dr. Barrois, a distinguished Member of this Association, had, with much forethought, and no little trouble and expense to himself, so admirably arranged all the details of each of the five days over which the excursion lasted as greatly to contribute to the pleasure and profit which the Members derived from it. In directing such special attention to the admirable arrangements, both scientific and otherwise, which marked the Boulonnais excursion, your Committee do not wish it to be supposed that less pains are taken in these respects with those which are conducted in this country, but only to mark their appreciation of what was done for the Members of the Association by French Geologists on that occasion.

Subjoined is a list of the excursions during the past year, giving their localities, Directors, and principal formations :—

LOCALITIES.	DIRECTORS.	PRINCIPAL FORMATIONS.
Chipping Norton.	Thos. Beesley, Esq., F.C.S. W. H. Hudleston, Esq., M.A., F.G.S.	Cornbrash, Forest Marble, Great Oolite—Upper and Lower Zones—Inf. Oolite, Upper and Middle Lias.
North Downs.	The President, and W. Whitaker, Esq., F.G.S., of the Geological Survey.	Oldhaven Beds, Chalk, Chalk Marl, Upper Greensand, Gault, Lower Greensand.
Tyler's Hill and Boxmoor.	John Evans, Esq., D.C.L., F.R.S., F.G.S. John Hopkinson, Esq., F.G.S., F.L.S.	London Clay, Woolwich and Reading Beds, Chalk.
Norwich and Cromer.	H. B. Woodward, Esq., F.G.S., of the Geological Survey; F. W. Harmer, Esq., F.G.S.; and Clement Reid, Esq., F.G.S., of the Geological Survey.	Valley Gravels, Glacial Deposits, Forest Bed, Norwich Crag, Chalk.
Hertford.	The President and John Hopkinson, Esq.	Glacial Deposits, London Clay, Woolwich and Reading Beds, Chalk, Greensand in boring.

Localities.	Directors.	Principal Formations.
Gorge of the Mole, Box Hill, and Dorking.	J. Logan Lobley, Esq., F.G.S.	Valley Gravels, Chalk, Up. Greensand, Gault, Lower Greensand.
Boulonnais.	M. Ed. Pellat, late President of the Geological Soc. of France; Dr. Chas. Barrois; Dr. Sauvage; Prof. Gosselet; M. Rigaux; and S. R. Pattison, Esq., F.G.S.	Post Tertiary, Up. & Lr. Chalk, Chalk Marl. Gault, Lower Greensand, Wealden, Up., Middle, and Lr. Oolites, Up. Coal Measures in a boring; Mt. Limestone and Devonian.

The thanks of the Association are due to the following gentlemen for assistance and hospitality at the Excursions:—

W. Gilford, Esq.
Dr. Gwyn Jeffries, F.R.S.
The Mayor of Boulogne.
The Scientific Societies of Boulogne.

Your Committee would congratulate the Association on the excellence and originality of many of the papers read at the monthly meetings—which were generally well attended—during the past year. The following is a list of these papers:—

On the Insect Fauna of the Secondary or Mesozoic Period, and the British and Foreign Strata in which Insect Remains have been detected, by H. Goss, Esq., F.L.S., F.G.S., &c.

On the Geology of Calcutta and the Delta of the Ganges, by S. Mackertich, Esq., C.E., Associate of King's College, London.

On the Lancashire Coal Fields, by C. E. de Rance, Esq., F.G.S.

Notes on a Well at Sheerness, by W. H. Shrubsole, Esq.

On some recent Discoveries among the Spongidæ—Living and Fossil, by W. J. Sollas, Esq., F.G.S.

On some Physical Properties of Precious Stones, by Professor A. H. Church, F.C.S. Specimens in illustration of his paper were exhibited by Professor Church.

On the Yorkshire Oolites, Part ii., Section 2. The Coralline Oolites, Coral Rag, and Upper Calcareous Grit, by W. H. Hudleston, Esq., M.A., F.G.S, &c.

Notes on the relations of the Igneous Rocks of Arthur's Seat, by the Rev. T. G. Bonney, M.A., F R S., F.G.S., Goldsmid Professor of Geology and Mineralogy, University College.

A Geological Sketch of the Boulonnais, by Dr. Chas. Barrois. This paper had a special reference to the Excursion of the Association to the Boulonnais.

On the Controversy respecting the Gneiss Rocks of the North-west Highlands, by W. H. Hudleston, Esq., M.A., F.G.S.

On the so-called "Crater Necks" and "Volcanic Bombs" of Ireland, by MATTIEU WILLIAMS, Esq., F.C.S., F.R.A.S.

On the Volcanic Region of Auvergne, illustrated by Specimens of Minerals and Diagrams, by W. F. BLACK, Esq., F.G.S.Ed.

In accordance with the usual custom, your committee have to announce the retirement of Professor Morris from the Chair, and in doing so they feel how unnecessary it is for them to say anything of one who has so thoroughly identified himself with this Association, whether in the Committee, at the Ordinary Meetings, or in the field. His great attainments as a geologist in every branch of that comprehensive science are well known, and not less by all who are personally acquainted with him the courtesy and affability with which he is ever ready to place these at the disposal of every one who wishes to profit by them.

Your Committee have much pleasure in being able to recommend Thos. Rupert Jones, Esq., F.R.S., F.G.S., Professor of Geology at the Royal Military College of Sandhurst, as the successor to Professor Morris. That gentleman is well known to the Members of this Association, both as an eminent geologist and as one to whom they are indebted for many valuable papers, and also for the interest he has always taken in its welfare.

We have still to thank the Council of University College for their liberality in allowing us the use of their spacious library in which to hold our monthly meetings.

Your thanks are also due to the Quekett Microscopical Club for the courtesy they have always shown us in lending their lamps whenever we have required them for exhibiting microscopical objects.

Your Committee have much pleasure in recommending for election as Honorary Member of the Association Dr. F. V. Hayden, United States Geologist, who, with his staff, has done so much in recent years for American Geology. The Library has benefited from the rich collection of reports and monographs which his liberality has supplied, and during the past year he has increased yet further our obligations in presenting us with his great Colorado Atlas, the most magnificent specimen of chartography which has ever yet proceeded from any survey on either side of the Atlantic.

Subjoined is the Balance-sheet of the Association for the year 1878.

BALANCE SHEET OF RECEIPTS AND DISBURSEMENTS

For the Year ending December 31st, 1878.

Dr.

		£ s. d.
By Balance, January 1st, 1878		113 11 0
,, Sale of Publications		1 6 11
,, January Dividend on £280 8s. 8d. (Consols) ...		4 8 1
,, July ,, £340 17s. 8d. ,, ...		5 0 2
,, Life Compositions		31 10 0
,, Entrance Fees	£11 10 0	
,, Annual Subscriptions	126 0 6	
		137 10 6
,, Donations to Library		2 0 0
		£295 1 8

Cr.

	£ s. d.
To Printing and illustrating "Proceedings"	61 18 0
,, Miscellaneous Printing	22 15 5
,, Library	34 0 5
,, Bought £60 9s. 6d. Consols	57 18 6
,, Broker's Commission	0 1 6
,, Fire Insurance to Dec. 31, 1878	1 17 6
,, ,, ,, Dec. 31, 1879	1 17 6
,, Postages	23 4 1
,, Stationery	1 11 7
,, Gas, Attendance, and Miscellaneous Items	15 7 8
Balance in hand	74 14 6
	£295 1 8

We have examined the Accounts of the Geologists' Association, and we find that, according to the books laid before us, a sum of £74 14s. 6d. remained in the hands of the Treasurer on the 31st December, 1878.

M. HAWKINS JOHNSON, }
JOHN J. YOUNG, } *Auditors.*

University College,
Feb. 3, 1879.

J. FOULERTON, M.D.,
Hon. Sec.

The Report of the General Committee was unanimously adopted as the Annual Report for the year 1878.

The Ballot having been completed, the President announced that the following had been elected :—

GENERAL COMMITTEE AND OFFICERS.

PRESIDENT.

Prof. T. Rupert Jones, F.R.S., F.G.S., &c.

VICE-PRESIDENTS.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.
Henry Hicks, Esq., M.D., F.G.S., F.R.C.S.
Wilfrid H. Hudleston, Esq., M.A., F.G.S., F.C.S.
Prof. John Morris, M.A., F.G.S., &c.

TREASURER.

F. G. Hilton Price, Esq., F.G.S., F.R.G.S., M.A.I.

HONORARY SECRETARY.

John Foulerton, Esq., M.D., F.G.S.

HONORARY LIBRARIAN.

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Rev. J. F. Blake, M.A., F.G.S.
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H. G. Fordham, Esq., F.G.S.
J. S. Gardner, Esq., F.G.S.
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M. Hawkins Johnson, Esq., F.G.S.
J. Logan Lobley, Esq., F.G.S., F.R.G.S.
Charles J. A. Meyer, Esq., F.G.S.
James Parker, Esq., F.G.S.
Henry Woodward, Esq., LL.D., F.R.S., F.G.S., &c.
T. J. Young, Esq., F.G.S.

Prof. Morris having vacated the chair, it was taken by the newly-elected President, Professor Rupert Jones, when the Thanks of the Meeting were given to the late President, to the Honorary Secretary, and to the Honorary Librarian for their services.

The Meeting then resolved itself into a Conversazione, at which a number of interesting Microscopical objects were exhibited.

The Insect Fauna of the Secondary or Mesozoic Period, and the British and Foreign Formations of that Period in which Insect Remains have been Detected.

By Herbert Goss, F.L.S., F.G.S., &c.

(*Read January 4th,* 1878.)

Introduction.

It will be unnecessary for me to make any preliminary observations in this Paper as to the importance of an acquaintance with Fossil Entomology, or as to the valuable conclusions bearing upon the geological conditions of the earth in former ages, which may be arrived at from a study of insect remains; such remarks as I had to offer on this subject having already been made in the introductory portion of my first Paper.

In the Secondary Rocks of this country fossil insects have been found far more frequently than in those of either the Recent or Tertiary age, and in some few localities these fossils are, comparatively speaking, abundant.

For such a knowledge as we have of the Insect Fauna of this country during the Secondary Period, we are indebted principally to the Rev. P. B. Brodie, F.G.S., who, as I have before remarked,[1] is the author of the *only*[2] *book* on fossil insects, either of this or any other period, which has been published in this country. In the determination of a large number of the insects described and figured in this book, as well as for some important introductory observations therein, Mr. Brodie had the advantage of the assistance of Professor Westwood[3] of Oxford.

We are indebted to Mr. Brodie not only for the interesting and valuable work just mentioned, but also for numerous papers on fossil insects, which have from time to time appeared in

[1] See Proc. Geol. Assoc., Vol. v., p. 285.

[2] "A History of the Fossil Insects in the Secondary Rocks of England." London, 1845: (Van Voorst.)

[3] Professor Westwood also contributed an important paper on Fossil Entomology, in the Quart. Journ. Geol. Soc., for 1854. Vol. x., pp. 378-396.

the [1] "Quarterly Journal of the Geological Society," "The Annals and Magazine of Natural History," "The Proceedings of the Warwickshire Naturalists' Field Club," &c.

Amongst the names of other contributors to our knowledge of fossil *Insecta* obtained from British strata of this Period, I must mention those of Mr. W. R. Binfield,[2] Mr. H. Binfield, Prof. Morris,[3] F.G.S., Dr. Mantell, F.R.S.,[4] Prof. Edward Forbes, F.R.S., Mr. W. R. Brodie,[5] Mr. C. Willcox,[5] the Rev. O. Fisher, F.G.S.,[5] Captain Woodley,[5] the Rev. Dr. Buckland, F.R.S.,[6] Mr. H. E. Strickland, F.G.S., Mr. A. G. Butler, F.L.S.,[7] Mr. S. H. Scudder,[8] and Mr. E. T. Higgins.

The British formations of this Period in which remains of insects have been found most plentifully, are the upper series of the Upper Oolite (*i.e.*, the Purbecks), and the Lias and Rhætics. The only other formations of this age in which they appear to have been yet discovered in the United Kingdom, are the Hastings Sands, and some other subordinate members of the Lower Cretaceous or Neocomian system, the Kimmeridge Clay, Oxford Clay (?), Forest Marble, Great Oolite, and the Stonesfield Slate.

Although the presence of insects in marine formations may be accounted for by supposing them to have been driven by the wind into the sea, when in its neighbourhood, or when attempting to cross it, yet, as a rule, where their remains have been detected in abundance in such formations, they may generally be considered as satisfactory evidence that land was not far distant at the time they were embedded; and the abundance of other terrestrial

[1] See "Athenæum," January, 1843. "Proceedings Geol. Soc.," Vol. iii., pp. 134, 135, and pp. 780-782. "The Annals and Mag. of Nat. Hist.," 1843, Vol. ii., p. 480. "Quart. Journ. Geol. Soc.," 1846, pp. 14-16. "Quart. Journ. Geol. Soc.," 1847, pp. 53, 54; Vol. v., pp. 31-35; Vol. ix., 1853 (pp. 51, 52); and Vol. x.,, 1854 (pp. 475-482). "The 35th Annual Report of the Warwickshire Natural History Society" (1871); and the "Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club," 1874, 1877, and 1878.

[2] "Quart. Jour. Geol. Soc." Vol. x., p. 171.

[3] "A Catalogue of British Fossils." London, 1854.

[4] "Medals of Creation," Vol. ii., p. 555; and "Quart. Journ. Geol. Soc.," Vol. ii., p. 96.

[5] "Quart. Journ. Geol. Soc.," Vol. x., antea cit.

[6] "Bridgwater Treatise," Vol. ii., p. 78; and "Phil. Mag.," 1844.

[7] "Lepidoptera Exotica," pp. 126-8; and "Geol. Mag.," Vol. x.

[8] "Fossil Butterflies," pp. 90-95 of the "Memoirs of the American Association for the Advancement of Science," No. 1, Salem, Mass., 1875.

remains, usually accompanying these fossils in such formations, leaves but little doubt upon the subject.

One notable exception to this rule is the Continental formation known as the Solenhofen Slate of Bavaria, in which insect remains are said to be mixed up, almost exclusively, with the *débris* of *marine* animals and plants.

Before proceeding to notice in detail the various formations of the Period from which fossil insects have been obtained, I think it may be interesting to call attention to the striking difference in the state of preservation of the insects from British strata of this period, with that of those from one of the most important of the Continental formations, *i.e.*, the Solenhofen Slate.

On the subject of the deposition of the Solenhofen insects, I will quote Dr. Hagen,[1] who observes—"On comparing the insects of Solenhofen and Eichstadt with those of England, there appears, in the first place, a difference which may possibly admit of interesting inferences; the insects of the Bavarian strata are almost universally preserved entire; wings, legs, head and antennæ are in their proper places; most of the *Libellulæ* have their wings expanded. He who has noticed on the sandy shores of the Baltic how depositions of insects are now taking place, will admit that the insects of the Solenhofen strata were already dead when deposited."

"The insects would be, as now, driven by the wind into the sea, thrown on the shore dead or dying, and there gradually covered with sand by the rippling waves. That this process took place gradually and slowly in the Solenhofen strata is evident also from another circumstance; for we frequently find the cavities of insects—the head, thorax and body—filled up with regular crystals of calcareous spar. Hence, the pressure of the stratum overlying the insects must have been very slight, when such delicate parts as the abdominal segments of a dragon fly could oppose resistance for a sufficient length of time to admit of the formation of crystals. Naturally there do occur, here and there, in the Solenhofen strata, impressions of insects obtained in a different way, which admit of the idea of a very heavy pressure from the superincumbent strata; yet these specimens are scarce, and form only a small proportion of the entire number."

Now the state of preservation of fossil insects obtained from

[1] See a paper read by Dr. Hagen before the Geological Section of the Brit. Assoc. at Manchester, Sept., 1861; and see the "Entomologists' Annual," for 1862, pp. 1-10.

British strata of this period is, as Dr. Hagen goes on to observe, in strong contrast to that of the Solenhofen insects. The fossil insects discovered in British formations of this age are seldom entire, and their remains generally consist of single wings, or parts of wings.

The imperfect condition of the English fossils may be accounted for on the supposition that their deposition did not take place in the manner of the Solenhofen insects, but only after they had for a long time been tossed about by storms or other commotions, or remained for years soddening in water.

On the Continent of Europe, so far as present discoveries enable us to judge, insect remains do not, as a rule, appear to have been found in the Secondary Rocks in any abundance; but to this rule the Solenhofen Slate of Bavaria, and the Lias of Schambelen in the Swiss Alps, form a striking exception.

For a knowledge of the fossil Insecta of the Solenhofen Slate, we are indebted chiefly to Professor Germar,[1] Count Münster,[2] Dr. Hagen,[3] and Herr H. Weyenbergh, jun.;[4] and to Professor Oswald Heer[5] we owe our knowledge of those from the Lias of the Swiss Alps.

Amongst the names of other students of the fossil Insecta of the Continental European formations of this period, may be mentioned — Schröter,[6] Schmiedel,[7] Esper,[8] Schlotheim,[9] Van

[1] "Ueber die Versteinerten Insekten des Juraschiefers von Solenhofen," Isis iv., pp., 421-424, 1837; and "Die Versteinerten Insekten Solenhofens," Acta. Akad. Leop. Car., t. 19, pp 187-222, 1839.

[2] "Beiträge zu. Petref.," t. 5, 1841.

[3] See "Enumération des Odonates fossiles d'Europe," at pp. 356-364 of "Revue des Odonates," by E. de Selys-Longchamps. Liège, 1850. The "Entomologists' Annual," 1862; and "Ueber die Neuroptern aus dem Lithographischen Schiefers in Bayern," "Palæontographica," Vol. x., pp. 96-145, 1861-1863; also "Die Neuroptern des Lithographischen Schiefers in Bayern;" "Palæontographica," Vol. xv., p. 57-96, 1865-1868.

[4] "Sur les insectes fossiles du calcaire lithographique de la Bavière, qui se trouvent au Musée Teyler;" "Archives du Musée Teyler," Vol. ii., pp. 247-294, Harlem, 1869; and Vol. iii., pp. 234-240.

[5] See "Die Urwelt der Schweiz" (1865), and a translation of the same into French, by M. Demole; also an English translation by W. S. Dallas, F.L.S., published under the title of "The Primæval World of Switzerland," and edited by J. Heywood, F.R.S. London, 1876.

[6] "Real und Verbal Lexicon," II., s. 93; III., s. 72, 1779; and "Neue Litteratur und Beitr. zur Kenntniss der Naturwissench.," T. 1, p. 410, 1784.

[7] "Vorstellung einiger Merkwürdiger Versteinerungen," Nürnberg, 1781.

[8] "De Animalibus Oviparis," &c., 1783.

[9] "Petrefactenk," p. 42, 1820.

der Linden,[1] Köhler,[2] von Buch,[3] von Meyer,[4] Geinitz,[5] Marcel de Serres,[6] Bronn,[7] Pictet,[8] C. von Heyden,[9] Giebel,[10] Ch. Brongniart,[11] and Winkler.[12]

I will now briefly review, in the descending order of geological succession, the various formations of this period in which insect remains have been detected, and the orders, families, genera and species, to which such remains have been referred.

GREAT BRITAIN.

LOWER CRETACEOUS OR NEOCOMIAN.

In the[13] Lower Cretaceous or Neocomian rocks remains of insects are extremely rare, and confined, so far as present discoveries enable us to judge, to the lowest members (Weald Clays and Hastings Sands) of the series.

The first discovered fossil insects from the Wealden were found in the neighbourhood of Hastings, by Messrs. W. R. and H. Binfield. They consisted of a few minute elytra of *Coleoptera*, and fragments of *Neuropterous* wings, and were obtained in the courses of ironstone exposed at low water-mark, at a place called the "Govers," [14] near St. Leonards-on-Sea. Above the course of the ironstone, in a bed of dark-coloured shale, many elytra of *Coleoptera* were found, as well as traces of wings of *Coleoptera, Neuroptera* and *Diptera*.

A few fragments of *Coleopterous* elytra have also been discovered

1 "Mem. Acad. Brux.," Vol. iv., p. 247, 1826.

2 Leonhard's "Zeitschr. für Min.," &c., T. 2, p. 231, 1826.

3 "Abhand. Berliner Akad.," 1837.

4 See Erichson und Grüber's "Encyclopædie," Sec. 2, xviii., p. 537, 1840; art. "Fossile Insekten aus dem lithographischen Schiefer."

5 "Characteristik der Kreidegebirge," p. 13; and "Grundriss der Versteinerungskunde," p. 187, 1846.

6 "Géognosie des Terrains Tertiaires," &c., Livre IV., sec. 3, p. 244, 1829.

7 "Lethea Geognostica," Vol. i., p. 210, 1835-1837.

8 "Traité élémentaire de Paléontologie," Vol. iv., 1846.

9 "Palæontographica," Vol. i., p. 99, 1851.

10 "Fauna der Vorwelt," 1856; and "Zur Fauna des lithographischen Schiefers von Solenhofen," T. 9, pp. 373-388, 1857.

11 "Annales de la Soc. Entomologique de France," v^{e} serie p. 217 (1876).

12 "Catalogue Systématique de la Collection Paléontologique" (Musée Teyler), 1876.

13 In this paper I have followed the arrangement of Sir Charles Lyell.

14 See a paper "On the occurrence of Fossil Insects in the Wealden Strata of the Sussex Coast," by W. R. and H. Binfield, communicated by Professor Morris, in the "Quart. Journ. Geol. Soc.," Vol. x., p. 171.

in the Wealden Marlstone, between Tonbridge and Maidstone, and are alluded to by Dr. Mantell.[1]

In the "Quarterly Journal of the Geological Society"[2] for 1854, Professor Westwood alludes to the discovery[3] by the late Edward Forbes, of some traces of fossil insects in the Hastings Series of the Isle of Wight, and of a few doubtful specimens by Mr. W. R. Brodie, in the Wealden of Punfield Bay, Swanage, Dorsetshire.

UPPER OOLITE.

Purbecks.

In the Rev. P. B. Brodie's interesting work on "The Fossil Insects of the Secondary Rocks of England," the Purbecks are referred to the Wealden formation; but modern Geologists are of opinion that, in consequence of the organic remains discovered therein, the Purbeck series has a close affinity to the Oolitic group, and that it should therefore be considered the newest or uppermost member of that formation, instead of the oldest or lowest member of the Wealden.

The Purbeck Beds are divided by Professor Edward Forbes into the Upper, Middle,[4] and Lower. It is from the middle and lower divisions that insect remains have been obtained in the greatest numbers. The great majority of these fossils were discovered by the Rev. P. B. Brodie, the Rev. Osmund Fisher, Mr. W. R. Brodie, Captain Woodley and Mr. C. Willcox.

In the "Quarterly Journal of the Geological Society"[5] for 1846, the Rev. P. B. Brodie recorded the discovery of a few imperfect remains of insects in Purbeck (?) strata in the neighbourhood of Swindon, Wilts.

A large collection of insect remains[6] was obtained by Mr. P. B. Brodie from the Middle Purbecks of Durl'ston Bay, Dorsetshire. These remains included elytra, bodies and wings of *Coleoptera*, *Orthoptera* and *Diptera*, and portions of the wings of *Neuropterous* insects.

1 See "Quart. Journ. Geol. Soc.," No. 34, Vol. ii., p. 96.
2 Vol. x., p. 378-396.
3 "Quart. Journ. Geol. Soc.," 1853.
4 See a paper on "The Dorsetshire Purbecks," by Professor E. Forbes. F.R.S., Brit. Assoc. Edinb., 1850.
5 "Quart. Journ. Geol. Soc.," 1846, Vol. iii., pp. 53, 54.
6 "See Quart. Journ. Geol. Soc.," 1854, pp. 378, 396.

A large collection of fossil insects was also obtained by Mr. Willcox from the Purbeck beds near Swanage; it consisted of some 60 slabs, each containing a number of remains. Professor Westwood says that the fossils obtained by Mr. Willcox included a very extensive series of elytra of *Coleoptera* (including *Buprestidæ* and *Harpalidæ*), also fragments of the wings of *Libellulidæ*, *Blattidæ*, *Tipulidæ*, &c.

Numerous fossil insects were obtained by the Rev. Osmund Fisher from the Ridgway Quarries (Lower Purbecks), near Dorchester.

The largest collection of insect remains from the Lower Purbecks was made by the Rev. P. B. Brodie. "It consisted," says Professor Westwood, "of 350 small slabs of stone of various sizes. Upon many of them only a single fragment of an insect occurs; but upon a considerable number the remains are very numerous, the fragments being crowded together, and often lying one upon another." These remains included quantities of elytra of *Coleoptera*, and also wings and wing covers of *Neuroptera* and *Orthoptera*, and two wings which were, for some time, supposed to be *Lepidopterous*.

The very fragmentary nature of these remains rendered the identification of the majority of them a matter of impossibility; but from Professor Westwood's paper in the "Quarterly Journal of the Geological Society,"[1] for 1854, and from the list of species in Dr. Giebel's "Fauna der Vorwelt,"[2] some 86 species seem to have been determined, viz :—

Coleoptera ...	... 45	species.	Hymenoptera ?...	2	species.
Orthoptera...	... 12	„	(very doubtful)		
Neuroptera	... 10	„	(supposed) Lepidoptera ? [3] ...	2	„
Hemiptera ...	... 11	„			
Diptera ...	... 4	„			

On the subject of these supposed remains of *Lepidoptera*, Mr. Scudder[4] observes, "I have not been able to find, even with Mr. Brodie's help, the first specimen referred to; but an examination of the original of the latter, proved that while it is unquestionably an insect, it cannot be referred to the *Lepidoptera*. As the figure of the first species clearly resembles, in this particular, the one I

[1] Vol. x., pp. 378-396.

[2] "Fauna der Vorwelt (Insecten und Spinnen"), Vol. ii., pp. 187 and 393-426.

[3] "Quart. Journ. Geol. Soc.," 1854, above cited. (See note 1, p. 124.)

[4] "Fossil Butterflies" pp. 88 and 89.

have seen, I am forced to the conclusion that neither of these wings is *Lepidopterous*."

The Purbeck strata in the Vale of Wardour in Wiltshire, consist, according to Mr. Brodie, of a series of clays, white limestones, grits, sandstones, coarse blue limestones, and fine white slaty limestone. In this last-mentioned limestone, insect remains have been detected in such abundance that it has been called—both here and in Dorsetshire—the "Insect Limestone." It was chiefly from this Limestone in the Vale of Wardour in Wilts, and the Vale of Aylesbury in Bucks, that the large collections of fossil insects were obtained which furnished materials for Brodie's "History of the Fossil Insects in the Secondary Rocks of England." Out of some 240 specimens, or parts of specimens, from these formations, 74[1] were figured by Professor Westwood in the work last mentioned. The very fragmentary and imperfect condition of a great quantity of the insect remains discovered in these formations rendered it impossible, even for so experienced an Entomologist as Mr. Westwood, to determine, in many cases, the species, or even the Orders to which they belonged.

A great many have, however, been identified, and, according to the list given by Mr. Brodie, in his "History of the Fossil Insects in the Secondary Rocks," and by Dr. Giebel, in his "Fauna der Vorwelt," the *Coleoptera*, *Orthoptera*, *Neuroptera*, *Hemiptera*, and *Diptera* are represented by some 65 species, distributed as follows, viz.:—

Coleoptera ...	... 18 species.	Hemiptera ...	... 14 species.
Orthoptera ...	... 10 ,,	Diptera ...	... 13 ,,
Neuroptera...	... 10 ,,		
			65

The *Coleoptera* appear to have been very well represented, and to have included *Buprestidæ*, *Carabidæ*, *Curculionidæ*, *Chrysomelidæ*, *Elateridæ*, *Cantharidæ*, *Tenebrionidæ*, &c. Mr. Westwood also detected amongst the insect remains from this formation, *Cercopidæ*, *Cimicidæ*, *Tipulidæ*, *Blattidæ*, *Aphidæ* and *Gryllidæ*.

On the subject of the remains from the Dorsetshire Purbecks, Professor Westwood observes, "With the exception of the Dragon flies, of which there are as many as 34 fragments of single wings

[1] See "Introductory Observations," by Professor Westwood, to Brodie's "History of the Fossil Insects in the Secondary Rocks of England.;" and the "Quart. Journ. Geol. Soc.," for 1854.

(from which, however, it is impossible to affirm either a moderate or tropical climate); and of a large ant (?) wing[1], it is worthy of remark that the whole of these remains, not fewer than 700 or 800, are those of minute insects, not more than a fourth or a third of an inch in length." Further on, in the same paper, he says, "If we take into consideration the small and even minute size of the great majority of the insects, and, indeed, of the whole of the *Coleoptera* which have been passed under review, the idea that we have before us the wreck of an Insect Fauna of a temperate region is at once raised; for, although it would be rash to assert that a mass of remains of the existing tropical insects might not be accumulated in which a large quantity of minute beetles and flies would not be present, yet I cannot conceive any process, either arising from currents of water or chemical dissolution of insect matter, which would carry off or destroy the many gigantic forms of insect life always occurring in the tropics. The fossils before us show abundant evidence of the presence of numbers of lignivorous species, such as the *Elateridæ* and *Buprestidæ*, but we nowhere find amongst them traces of the great *Lamellicorn* and *Longicorn* Beetles. Herbivorous insects also occur in considerable numbers, but we do not meet with the gigantic Grasshoppers and Locusts of tropical climates."

Entomologists[2] are aware that sudden inundations, or the rapid rising of rivers, are sure to bring with them vast quantities of insects which are carried away by currents in great numbers, and congregated together in masses.

It appears that, with a few exceptions, there is a very general conformity between the insects from the Dorsetshire Purbecks and those of Wilts and Bucks. There would, however, appear to have been a great difference in the manner of deposition of the strata of the two districts, as evidenced by the remarkable contrast presented by *the state of preservation* of the insects of the Wiltshire Purbecks,

[1] Prof. Rupert Jones, F.R.S., has informed me that the ant wing was not obtained from Purbeck strata. See his letter at p. 348, Vol. vii., of the "Geol. Mag.," July, 1870.

[2] In a letter dated the 20th July, 1878, Mr. Alfred Russell Wallace remarks that "the quantity of insects carried down and drowned during floods is enormous. About 30 years ago the late T. V. Wollaston gave an account in the 'Zoologist' of his entomologising in South Wales, among the *débris* left by a flood. The *débris* literally swarmed with insects, especially beetles, and he obtained an enormous haul, including many excessively rare species."

and that of those of the Dorset Purbecks. In the *former* numbers of specimens are in a fair state of preservation, while in the *latter*, the remains consist, almost always, of fragments of wings, elytra or bodies.

Kimmeridge Clay.

Mr. P. B. Brodie [1] states that at Ringstead, in Dorsetshire, this Clay is traversed by a bed of sandy laminated stone, about two feet thick, and this is succeeded by dark-coloured shale and clay, containing large blocks of Septaria, in one of which he discovered a striated elytron of a small Beetle.

With this exception, I have been unable to find any record of the discovery of insect remains from this part of the Upper Oolite.

MIDDLE OOLITE.

Oxford Clay.

The only trace of an insect from this division of the Oolite was found by Mr. J. C. Pearce, near Christian Malford. Professor Westwood thought that this fossil might possibly be that of a larva of a *Libellula*.[2]

LOWER OOLITE.

Forest Marble.

The only record of the discovery of fossil insects from this part of the Oolite is made by Mr. P. B. Brodie, who states that in some of the quarries in this series at Farleigh, near Bath, he found a few elytra of small Beetles.

Great Oolite.

Elytra of *Coleoptera*[3] are recorded from the Great Oolite in the eastern Moorlands of Yorkshire. The discovery of these remains is also alluded to by Dr. Mantell[4] in the "Medals of Creation."

[1] See the "Quart. Journ. Geol. Soc." Vol. ix., p. 51. 1853, and a paper "On the Distribution and Correlation of Fossil Insects," by the Rev. P. B. Brodie, Warwick, 1874.

[2] Figured by Brodie in his "Fossil Insects," plate iv., fig. 13.

[3] See Brodie's paper "On the Distribution and Correlation of Fossil Insects," antea cit.

[4] See the "Medals of Creation," Vol. ii., p. 555. See also the "Bridgwater Treatise," Vol. ii., p. 78; also "Loudon's Mag. of Nat. Hist.," Vol. iii., p. 361. In a note at page 379 of the "Quart. Journ. Geol. Soc." for 1854, reference is made by Professor Westwood to a fossil insect having been discovered by Professor Morris in the Great Oolite of Lincolnshire.

STONESFIELD SLATE.

The remains of insects in this formation appear to be almost confined to a few families of *Coleoptera*, and they are generally in a very fragmentary condition, and consequently most difficult to determine.

Dr. Buckland has described the wing of a large *Neuropterous*[1] insect from the Stonesfield Slate, which has been named *Hemerobioides giganteus*;[2] and in the list at the end of Mr. Brodie's paper "On the Distribution and Correlation of Fossil Insects" another specimen of a *Neuropterous* insect is enumerated (*Libellula Westwoodi*), besides two large wings, referred to the *Libellulidæ* which were found at Eyeford on the Cotswolds, by Mr. Brodie.

The remains of *Coleoptera* from this Slate have been referred by Brodie and Westwood to some seven families, including *Buprestidæ*, *Curculionidæ*, *Coccinellidæ*, *Prioniidæ*, &c.

By far the most interesting fossil insect from the Stonesfield Slate is the wing of a large species which Professor Westwood, Mr. Bates, and Mr. Butler believe to be *Lepidopterous*. In the[3] "Proceedings of the Entomological Society of London" for 1872,[4] we find the following notice of its exhibition at a meeting of that Society. "Mr Butler exhibited a remarkably perfect impression of the wing of a fossil butterfly, in the Stonesfield Slate. It appeared to be most nearly allied to the now existing South American genus, *Calligo*." Mr. Butler[5] subsequently named this fossil *Palæontina Oolitica*, and described and figured it in his "Lepidoptera Exotica." He observes—"Though a British insect, this species belongs to a group so completely tropical, that I do not hesitate to describe and figure it in the present work; its nearest allies are the genera *Calligo*, *Dasyophthalma*, and *Brassolis*, all three essentially tropical American genera. *P. Oolitica* is especially interesting as being the oldest fossil butterfly yet discovered; the most ancient previously known to Science (*Neorinopis sepulta*)

[1] See "Geol. Proc.," Vol. ii., p. 688, and Mantell's "Medals of Creation," Vol. ii., p. 552.

[2] Dr. Hagen states that this insect should be referred to *Apochrysa*

[3] Page xxxvi., 1872.

[4] See Sir Sidney Smith Saunders's observations on this fossil in his Anniversary Address to the Entomological Society (when President of that Society) in January, 1874.

[5] See "Lepidoptera Exotica" pp. 126-8, by A. G. Butler. It was also described and figured in the "Geological Magazine," Vol. x.

having been found in the[1] Cretaceous series (white sandstone of Aix la Chapelle) whilst the bulk of the known species are from the Lower Miocene beds of Croatia; it is also interesting as belonging to the highest family of butterflies, and to a sub-family intermediate in character between two others, viz., the *Satyrinæ* and *Nymphalinæ*, whilst the more recently discovered fossils are referable, with one exception, to the two latter groups. The nervures appear to have been impregnated with iron, which will partly account for their well defined condition."

Mr. Scudder, who states that he carefully examined the original fossil, considers Mr. Butler to be in error in referring this wing to a *Lepidopterous* insect, and is of opinion that it should be considered *Homopterous*, and allied to *Cicada*.

Mr. Butler has himself directed my attention to the neuration of this wing, as figured, and also to that of some of the *Cicadæ* in the British Museum Collection, and from a comparison of figures of the wing with these insects I am inclined to agree with Mr. Butler, who in his view is supported by Professor Westwood and Mr. Bates. At the same time, as we have no evidence of the existence of true flowers at this period, there seems a certain amount of probability in favour of the correctness of Mr. Scudder's opinion as to the insect not being *Lepidopterous*.

Since the date of the discovery of *P. Oolitica*, another fragment of a supposed fossil butterfly has been found in the Stonesfield Slate, and is, or was until quite lately, in the possession of J. Parker, Esq., of Oxford. This fossil[2] has not yet, I believe, been figured or described.

LIAS AND RHÆTICS.

The Lias, including therein the Rhætic series, is in *this country*, the oldest formation of the Secondary Period in which fossil insects have been detected.

In some sections of this formation insect remains have been discovered in such abundance that the beds containing them have, as

[1] This is an error of Mr. Butler's: the insect was found at Aix, in Provence, in strata belonging to the Upper Eocene period.

[2] In January, 1878, I was informed by Prof. Westwood that this fossil was too fragmentary to admit of its being referred with certainty to the *Lepidoptera*, or any other order. Jan. '79.

in the "Purbecks," been called the "Insect Limestone." Fossil insects have been found, chiefly in the lower division of this formation, in Gloucestershire,[1] Worcestershire, Warwickshire, Somersetshire, Dorsetshire and on the borders of Monmouthshire; a few have also been found in Yorkshire.[2] They are generally in a much more fragmentary condition than those from the "Purbecks," and are less common than in the latter formation.

Mr. Brodie states that he first discovered these interesting fossils in the immediate neighbourhood of Gloucester, and[3] he adds that some of the beds of limestone in the lowest division of the Lias, in the Vale of Gloucester, abound in insects, and that beautiful specimens, chiefly elytra and wings, have also been found in the Upper Lias at Dumbleton and Alderton.

At Dumbleton, which is N.E. of Cheltenham, Mr. Brodie obtained from the Upper Lias shales one nearly perfect *Neuropterous* insect, of which Professor Westwood[4] says—"It possesses an arrangement of the wing veins differing from that of any English species, and also from any foreign species known to me, but it comes nearest to the small *Libellulæ* forming the genus *Diplax*."

In the Upper and Middle portions of the Lower Lias, which are extensively developed in the neighbourhood of Gloucester and Cheltenham, traces of insects are said to be exceedingly scarce, but at Wainlode Cliff, on the banks of the Severn, near Gloucester, the Insect Limestone has produced remains of several genera of *Coleoptera*. In the Insect Limestone, to the South West of Combe Hill, not far from the last mentioned locality, Mr. Brodie obtained a great number and variety of insect remains, consisting

[1] In a note at p. 378 of the "Quart. Journ. Geol. Soc.," Vol. x., 1854, Prof. Westwood states that "A rich collection of fossil insects, from the Lias of Gloucestershire, &c., has been made by W. R. Binfield, Esq., to whom also the Museum of the Geol. Soc. is indebted for a suite of insects from the Lias of Lyme Regis." I am not aware that these insects have ever been described.

[2] The Rev. J. F. Blake has described and figured two fragments of insects from the Yorkshire Lias. One specimen consists of an elytron of a beetle, named by Mr. Blake *Buprestites bractoides*, and the other specimen consists of two wings of a *Neuropterous* insect, apparently belonging to some species allied to *Chauliodes*, which Mr. Blake has named *Chauliodites minor*. See "The Yorkshire Lias," by Ralph Tate, and J. F. Blake. London, 1876, p. 426, and plate xvi., figs. 5 and 6.

[3] See Brodie's "Fossil Insects," p. 51-103, and the "Quart. Journ. Geol. Soc.," Vol. iv., 1846, p. 14-16.

[4] See "Quarterly Journal of the Geological Society," Vol. v., 1849, p. 31-35.

chiefly of the elytra of *Coleoptera* and a few imperfect but large wings of *Libellulidæ*.

At Apperley, near Wainlode Cliff, remains of insects have been found in plenty, many small slabs, three or four inches square, exhibiting several elytra and wings, and a few small Beetles.

From the Insect Limestone, near the village of Hasfield, Gloucester, many elytra of *Coleoptera* have been obtained. The same formation, in the neighbourhood of Forthampton near Tewkesbury, has also furnished fossil insects, belonging to the same families as those found in the localities before mentioned.

At Strensham, about nine miles from Evesham, insects have been obtained from a bed of Insect Limestone at the bottom of a large quarry. Amongst them was found part of the abdomen of a gigantic species of *Libellula*, which Mr. Brodie named *Libellula Hopei*. In the neighbourhood of Evesham the Insect Limestone has produced numerous remains of insects, the wings and elytra of many of which are said to be beautifully preserved. In the Lower division of the Lias, in this neighbourhood, Mr. H. E. Strickland[1] discovered small elytra of *Coleoptera* and portions of the wings of *Libellulidæ*.

From one quarry near Bidford, Warwickshire, Mr. Brodie obtained a small species of the family *Gryllidæ*, which he named *Gryllus Bucklandi* in honour of Professor Buckland.

In some of the quarries in this neighbourhood (Bidford) the wings of *Libellulidæ* were obtained not uncommonly, particularly at a place called the "Nook," where a beautiful specimen was found, which has been described and figured by Mr. Strickland.[2]

Mr. E. T. Higgins obtained from the Lower Lias or the Rhætics, in the Southern parts of Gloucestershire and the adjoining County of Somersetshire, in the neighbourhood of Bristol, numerous remains of insects. From Aust, near Bristol, and from Sudbury, on the Monmouthshire side of the Severn, about three miles from Chepstow, the Insect Limestone and the "Landscape Stone" have afforded a quantity of remains. In some slabs the insects were found embedded together in masses. In one slab Mr. Higgins is stated to have detected as many as 30 small Beetles.

[1] "Quart. Journ. Geol. Soc.," 1846, Vol. iv., pp. 14-16.

[2] See "The Annals and Magazine of Natural History," Vol. iv., p. 301, (new series).

From the frequency of such delicate creatures as insects in the Landscape-stone, and in another band of limestone only a few feet higher, some of which are said to be beautifully preserved, and could not have been long subject to the action of the waves, it is supposed by Mr. Brodie, that this part of the Lias may have been formed in an estuary, which received the waters of some neighbouring coasts, and which brought down the remains of insects and plants.

The *Coleoptera* appear to have been abundant in the Lias, for out of some 300 specimens, or parts of specimens of insects obtained from this formation, examined by Professor Westwood, more than one third were referred by him to this Order, and included representatives of the *Buprestidæ*, *Elateridæ*, *Curculionidæ*, *Chrysomelidæ*, *Carabidæ*, *Telephoridæ*, &c. Most of the species appear to have been very minute, "never equalling in size," observes Mr. Westwood, "those from the Stonesfield Slate." The other orders represented in this formation are the *Orthoptera*, the *Neuroptera*, the *Hemiptera*, and (possibly) the *Diptera*?

The remains of *Orthoptera* include *Gryllidæ* and *Blattidæ*; the *Hemiptera* include *Cicada* and *Cimex*, and the *Neuroptera*, *Libellula*, *Agrion*, *Orthophlebia*, *Hemerobius*, *Æschna*, *Chauliodes* and *Ephemera*. Among these various families and genera we have omnivorous, herbaceous, and predaceous species. Many of the families and genera found in the Lias are common both to it and the Purbecks.

Although, as a rule, the remains of insects from this formation are very imperfect and fragmentary, the detached wings of many *Neuropterous* insects are preserved in the greatest perfection, and have the nervures of the wings beautifully defined. The size of the insects, judging from the remains, appears to have been usually small and indicative of a temperate climate.

It may be observed that nearly all the fossil insects from this formation have, with the exception of a few specimens from the Upper division, been obtained from the *lowest*[1] division of the Lias, or from the Rhætic series, between the Lias and the Trias. Remains of insects from the Lias and Rhætics are very numerous, but the majority of them are in such a fragmentary condition that

[1] Since this paper was read in January, 1878, I have received from Charles Moore, Esq., F.G.S., of Bath, a large collection of fossil insects from the *Upper* Lias of Ilminster. This collection includes *Coleoptera*, *Neuroptera*, *Orthoptera*, &c., all of which I hope shortly to describe.

it has been impossible, even for those who have devoted special attention to the subject, to make out the species to which they belong. About 56 species, however, have been determined, which are distributed amongst five orders as follows, viz. :—

Coleoptera	... 29 species.		Hemiptera	...	6 species.
Neuroptera	... 12 „	(supposed)	Diptera?	...	2 „
Orthoptera	... 7 „				

No traces of *Lepidoptera* or *Hymenoptera* have been met with, and the remains which have been referred to the *Diptera* are extremely doubtful.

CONTINENT OF EUROPE.

CRETACEOUS.

As the Upper Cretaceous Rocks are, for the most part, of marine origin remains of insects are, of course, very rarely met with in them.

From certain beds of sand in the neighbourhood of Aix la Chapelle, which have been referred to the Upper Cretaceous Period, Dr. Debey[1] obtained about ten species of *Coleoptera*, chiefly *Curculionidæ* and *Carabidæ*.

Professor Pictet[2] states that M. Desmoulins found elytra of *Coleoptera* in the Chalk Marl of the Mountain of St. Catherine, near Rouen.

Dr. Geinitz has called attention to the remains of perforated wood in the Upper and Lower Greensands of Saxony, which he considers to be evidence of the existence of Longicorn Beetles at this period. He believes that the insects, which made these perforations, belonged to the *Cerambycidæ*.

M. Charles Brongniart[3] in April, 1876, called the attention of the Entomological Society of France to a piece of fossil wood, obtained from the Gault of Lottinghem, Pas de Calais, containing numerous perforations. M. Brongniart believes these perforations to have been made by some species of beetle belonging to the genus *Hylesinus*, of the family *Scolytidæ* (Xylophaga.)

[1] Lyell's "Elements," 6th edit., page 331.

[2] "Traité élémentaire de Paléontologie," Vol. iv., pp. 95 and 102.

[3] See "Les annales de la Société Entomologique de France," Ve serie., p. 217. 1876.

UPPER OOLITE.

SOLENHOFEN SLATE.

The most celebrated formation of this period on the Continent, from which fossil insects have been obtained in any number, is that of the well-known lithographic stone of Solenhofen,[1] in Bavaria.

The oldest account of fossil insects from this formation is found in Schröter's [2] "Real-und verbal Lexicon," published in 1779. In 1783 Esper [3] referred to the discovery of a species of *Gryllus* in the Solenhofen Slate; and in 1826 [4] Van der Linden described a *Neuropterous* insect from Solenhofen, as *Æschna antiqua.*

Reference to fossil insects from the Solenhofen slate is also made by Marcel de Serres,[5] in 1829; and Bronn,[6] in 1835, enumerated *Coleoptera, Neuroptera, Hymenoptera* and *Lepidoptera* (?) from the same formation.

In 1839[7] Professor Germar[8] published descriptions of 17 species from Solenhofen, including *Coleoptera, Orthoptera, Neuroptera, Hymenoptera, Hemiptera,* and *Diptera.* Several species from this locality were also described (in 1841) by Count Münster,[9] including a *Lepidopterous* (?) insect,[10] which he referred to the *Tineina.*

[1] Of this formation, Lyell observes — "Although the number of *Testacea* in this Slate is small, and the plants few, and those all marine, Count Münster had determined no less than 237 species of fossils, including 26 species of insects. These insects, among which is a *Libellula* or dragon-fly, must have been blown out to sea, probably from the same land to which the flying lizards and other contemporaneous reptiles resorted.'

[2] "Real und verbal Lexicon," 1779, II., s. 93; III., s 72; and in "Neue Literatur und Beiträge zur Kenntniss," Leipsic, 1784, I. c., 410.

[3] "De animalibus oviparis." pp. 18-19, Erlangæ, 1783.

[4] "Mem. Acad. Brux.," Vol. iv., p. 247, 1826.

[5] "Géognosie des terrains Tertiares," &c Livre iv$^{me.}$ Sec. iii., p. 244, 1829.

[6] "Von Insekten einege *Käfer (Cerambyx, Hydrophylus), Neuropteren (Libellula, Aeschna, Agrion, Myrmeleon), Hymenopteren (Sirex, Ichneumon).* Schmetterlinge *(Sphynx),*" &c. "Lethea Geognostica," Vol. i., p. 210. 1835-1837. (See also Quenstedt. "Handb. d. Petrefaktenk.")

[7] "Nova Acta. Akad. Leopold. Carol.," 1839, xix., 2 s., 187-222, t. 21-23.

[8] Dr. Hagen observes of these insects:—"The species described by Germar, in the 'Acta Acad. Leop.,' to which hitherto reference has always been made, are described from specimens, the outline of which has been artistically painted and completed. I have often examined the types carefully, and can certainly maintain that this account of them is correct." "Entomologists Annual," 1862, p. 1.

[9] "Beiträge zur Geognosie und Petrefactenkunde," Bayreuth, 1841.

[10] Of this insect M. Pictet observes, "Le Comte de Münster a décrit, sous le nom de '*Tineites Lithophilus*' un insecte des Schistes Lithographiques de Bavière, qu'il considère comme appartenant à la famille de Tineides, mais que la vue de la figure me ferait plutot considerer comme un *Termes.*" —"Traité de Paléontologie," Vol. iv., p. 111.

Dr. Giebel, in his "Fauna der Vorwelt,"[1] (Insecten und Spinnen), published in 1856, enumerates 26 species from Solenhofen, including—

Coleoptera ...	... 2 species.	Hemiptera ...	... 4 species.
Orthoptera ...	... 4 "	Lepidoptera (?)	... 1 "
Neuroptera ...	... 12 "	Diptera ...	... 2 "
Hymenoptera	... 1 "		

Dr. Hagen,[2] who has paid especial attention to the Solenhofen *Neuroptera*, has described 33 species of that Order, and has also given a list of 36 species contained in the Royal Collection in the Academy of Munich.

Of the 36 species of *Neuroptera* in the Munich Collection, Dr. Hagen states that 27 are dragon flies, some of which belong to extinct genera, but others to such as now live in America and Australia; he also[3] adds that many of the fossil insects from this formation, preserved in the Munich Collection, and in the Collection of Dr. Krantz, of Bonn, are in a splendid state of preservation. One-third of the entire collection is *Libellulidæ*, another third consists of *Orthoptera* and *Hemiptera* (especially gigantic species of *Belostoma*, *Pygolampos* and *Nepa*); and the remaining third consists of *Coleoptera*, *Hymenoptera* and *Diptera*. Out of 450 specimens of fossil insects in the Munich Collection 150 are *Neuroptera*, and out of these 136 belong to the *Odonata*.

The *Odonata*, according to Hagen, comprise the following, viz:—

Libellulina ...	... 4 species.	Calopterygina	... 11 species.
Æschnina ...	... 1 "	Agrionana ...	... 4 "
Gomphina ...	... 7 "		

The *Gomphidæ* are said to belong principally to species referable to genera similar to *Petalia*, *Phenes*, and *Petalura*, of which a few species occur at the present day in Chili and Australia. The fossil *Gomphina* of Solenhofen, are generally very large, and some are truly gigantic[4]—four inches in length, with an expanse of wings of 7½ inches.

Of the *Calopterygina*, the group *Heterophlebia* contains some of

[1] "Fauna der Vorwelt," II. (Die Insecten und Spinnen der Vorwelt), s. 392 to 426. 1856.

[2] "Ueber die Neuropteren aus dem lithographischen Schiefers in Bayern," in "Palæontographica," Vol. 10, pp. 96-145. 1862. "Palæontographica," Vol. XV., 1865-1868, and the "Entomologists' Annual," for 1862.

[3] See "Entomologists' Annual" for 1862.

[4] See the plates accompanying Dr. Hagen's papers, in "Palæontographica," Vols X. and XV., antea cit.

the most gigantic *Neuroptera*—two of them belong to the largest known *Odonata*, having an expanse of wing of 7½-8 inches, and bodies 3¾-4 inches in length.

From a study of the fossil insects from the Solenhofen Slate, and a comparison of them with those from the English formations of the same age, Dr. Hagen has drawn two conclusions, viz.:—(First.) That the two fauna are very closely allied, and that possibly some species occur in both formations. (Secondly.) That the fauna of the English and Bavarian strata are not only quite distinct from the existing fauna, but also from those of Aix; of the Rhenish peat deposit (Brown Coal of the Rhine); of Œningen and Radoboj; and from that of the Amber; differing not only in species but in genera.

Another large collection of fossil insects from Solenhofen is contained in the Teyler Museum at Harlem. Upwards of 80 species in this collection have been described by Herr H. Weyenbergh[1] junr., in the "Archives du Musée Teyler," and are enumerated by Dr. Winkler,[2] in his 2nd Supplement to the "Catalogue Systématique de la Collection Paléontologique du Musée Teyler."

The species obtained from the Solenhofen Slate which have up to the present time been described by Prof. Germar,[3] Count Münster,[4] Herr Carl von Heyden,[5] Dr. Giebel,[6] Dr. Hagen,[7] and Herr H. Weyenbergh,[8] amount in number to 114[9] and are distributed amongst the existing Orders as follows:—

Coleoptera ...	... 29	species.	Diptera ...	... 5	species.
Neuroptera ...	... 46	„	Hymenoptera	... 5	„
Orthoptera ...	... 11	„	Lepidoptera	... 2	„
Hemiptera ...	... 16	„			
				114	

1 "Sur les Insectes fossiles du calcaire lithographique de la Bavière qui se trouvent au Musée Teyler" Archives du Musée Teyler.—Vol. ii., pp. 247-294, 1869. Vol. iii., pp. 234-240, and "Period Zool. Arg." t. 1.

2 "Catalogue Systématique de la Collection Paléontologique du Musée Teyler." Harlem 1876, (Deuxième Suppt.)

3 "Nova Acta. Acad. Nat. Cur." T. xix. 1839.

4 "Beiträge zu Geog. und Petref," 1841.

5 "Palæontographica." Vol. i. pp. 99-101, 1851.

6 "Fauna der Vorwelt." Vol. ii., 1856. and "Zur fauna des Lithographischen Schiefers von Solenhofen." 1857.

7 "Enumeration des Odonates fossiles d'Europe" "Revue des Odonates" by E. de Selys-Longchamps, pp. 356-364, 1850; "Palæontographica," Vol. x., 1861. 1863; Vol. xv., 1865, 1868; and the "Entomologists' Annual." 1862.

8 "Archives du Musée Teyler," &c., antea cit.

9 For lists of species see post pages 148 & 149.

This list is especially important, as it includes two undoubted species of *Lepidoptera*.

LIAS.

From the lower marls of the Lias, at Schambelen in the Canton of Aargau, in Switzerland, about 2,000 specimens of fossil insects have been obtained. These specimens have been carefully studied by Professor Heer, who is of opinion that this locality is the only one on the Continent, in which so large a number of primæval insects have been preserved to our time.[1]

The 2,000 specimens comprise 143 species, which are distributed as follows :—

	Species.		Species.
Coleoptera	116	Hemiptera	12
Orthoptera	7	Hymenoptera ? (very doubtful)	1
Neuroptera...	7		143

No *Lepidoptera* or *Diptera* have as yet been discovered. One small wing is described as being that of a *Hymenopterous* insect, but as no remains of the *Hymenoptera* have been obtained elsewhere from strata of this period—even in those localities in which insect remains have been found in abundance—it is probable that this wing belonged to an insect of another Order.

The *Coleoptera*[2] are represented by some sixteen families, amongst which are *Carabidæ, Gyrinidæ Cryptophagidæ, Nitidulidæ, Peltidæ, Cistelidæ, Rhyncophora, Chrysomelidæ, Byrrhidæ, Hydrophilidæ, Buprestidæ, Elateridæ, Telephoridæ,* &c.

The presence, in large numbers, of those beetles whose larvæ are wood feeders, and who in their perfect state are usually found on or under the bark of trees, is evidence of the existence of woods or forests during this period ; and the presence of several genera of fungus beetles implies the existence of fungi. The *Buprestidæ* are represented by 33 species. Of the *Byrrhidæ* four species have been found in this formation ; three of them—*Byrrhidium arcuatum, B. morio,* and *B. troglodytes*—are among the most abundant insects at Schambelen, and as they are all moss feeders, Professor

[1] "Urwelt der Schweiz," *antea cit.*
[2] For list of families, see post-page 149.

Heer supposes that the ground and the trees were more or less covered with mosses, although no remains of these plants have been preserved. The leaf-eating beetles are represented by, amongst other species, two of the family *Chrysomelidæ*. Of Carnivorous beetles 29 species have been found, and the Water-beetles are represented by some 20 species.

The *Orthoptera* comprise three species of *Blattidæ* (cockroaches), three grasshoppers, and one earwig; and the *Neuroptera* are represented by six species of *Termites* (or white ants) and one dragon fly—*Æschna Hageni*—which is perhaps larger than any living[1] species, except *Gynacantha plagiata*.

The *Hemiptera* include nine species, distributed amongst the *Cercopidæ*, *Lygæidæ*, and *Cicadidæ*.

Dr. Heer observes that it may be safely inferred from the richness of the insect fauna that the land was of considerable extent. Some of the insects are of large size, but the majority are small, some even smaller than the smallest of the allied species of the present day, as is also the case with the insects of the English Lias. Judging from the size of the Liassic insects, one would infer a temperate climate, but the numerical proportion existing between certain families tends to the conclusion that a warmer climate then prevailed.

So far as I am aware the only other locality on the Continent in which insect remains have been discovered in the Lias, is Bayreuth,[2] where Count Münster is said to have detected traces of wings of insects.[3]

TRIAS.

No traces of insects have as yet been found in the Triassic rocks of the United Kingdom, and only seven specimens have been recorded from Continental Europe. Of these seven specimens three have been referred to the *Coleoptera*, three to the *Neuroptera*, and one to the *Orthoptera*.

The three species of *Coleoptera* have been described by Dr.

[1] See plate iv. in pt. 1, " Trans. Ent. Soc., London," 1878.
[2] Bronn's " Lethea Geognostica," Vol. i., p. 210.
[3] Since this paper was read in January, 1878, seven species of *Coleoptera* have been described by Dr. Heer from the Rhætic formation of Schonen, in Sweden. (See " Aftryck ur Geol. Föreningens i Stockholm Förhandl," 1878, No. 49, Bd. iv., No. 7).

Heer,[1] and respectively named *Glaphyroptera pterophylli*, *Curculionites prodromus*, and *Chrysomelites*[2] *Rothenbachi*; the two first-named were discovered in the Keuper of Vadutz, and the third specimen was obtained from the Keuper of Rothenbach.

The three specimens of *Neuroptera*[3]—*Chauliodites Picteti*, *C. Zinckeni*, and *C. Helveticus*—have also been described by Dr. Heer. The two first named specimens were obtained from the Bunter of Trebitz and Salzmunde, and the third specimen from the Keuper.

The only *Orthopterous* insect from the Trias was also obtained from the Bunter of Trebitz. It belongs to the family *Blattidæ* (cockroaches), and has been described[4] by Dr. Heer, who placed it in a new genus—*Legnophora*—and named it *Girardi*, after Prof. Girard, of Halle, in whose collection it was discovered.

This specimen concludes the scanty list of fossil insects obtained from the Trias of Continental Europe.

AMERICA.

TRIAS.

In the "Geological Magazine" for May, 1868, Mr. Scudder records one species of *Coleoptera* from the Trias of North America, and he observes that "in the Triassic rocks of the Connecticut Valley some questionable tracks have been referred by Hitchcock to Insects[5] and Myriopods."

I have lately been informed[6] by Mr. Scudder that a vast quantity of insects from Secondary rocks have been recently discovered in America, and will be described by him in due course.

The following is, I believe, a complete list of all the fossil insects which have, up to the present time, been described from the Secondary formations of the United Kingdom and the Continents of Europe and America.

[1] See "Le Monde Primitif de la Suisse," p. 99; "Neuer Denkschriften der Schweiz Naturforsch Gesellschaft." xiii, 1853 (figured in Taf. vii.).
[2] "Flora Foss. Helveticæ," p. 76, Taf. xvii., 1877.
[3] "Vierteljahrsschrift der Naturforschenden Gesellschaft in Zurich," p. 279. 1864.
[4] "Vierteljahrsschrift der Naturf. Gesellsch. in Zurich," 1864, *antea cit.*
[5] See also Dana's "Manual of Geology," 1874, p. 411.
[6] *In litt.*

A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE SECONDARY OR MESOZOIC PERIOD.

EUROPE.

GREAT BRITAIN.

LOWER CRETACEOUS OR NEOCOMIAN.

From Ironstone[1] and Shales at the "Govers," near St. Leonards-on-Sea :—

Elytra of Coleoptera and wings or parts of wings of Coleoptera, Neuroptera and Diptera.

From the Wealden Marlstone between Tonbridge and Maidstone :—

Elytra of Coleoptera.

From the Wealden of the Isle of Wight :—

Elytra of Coleoptera.

From the Wealden of Punfield Bay, Swanage, Dorsetshire :—

Elytra and wings of insects.

UPPER OOLITE.

MIDDLE AND LOWER PURBECKS.

From Durl'stone Bay, Swanage, Dorset :—

COLEOPTERA.[2]

Hydrophilus Brauni.	Cymindis Beyrichi.
Hydroporus Neptuni.	,, antiqua.
Carabus Westwoodi.	Buprestium gorgus.
Carabidium Dejeananum.	,, stygnus.
Harpalus Knorri.	,, Woodlei.
,, Ewaldi.	,, dardanus.
,, anactus.	,, bolbus.
,, Burmeisteri.	Ancylochira teleas.
Harpalidium nothrus.	Agrilus strombus.

[1] See a paper "On the occurrence of Fossil Insects in the Wealden Strata of the Sussex Coast' "Quart. Journ. Geol. Soc.," Vol. x., p. 171, 1854.

[2] This list is compiled from Prof. Westwood's paper in the "Quart. Journ. Geol. Soc.," Vol. x., Nov., 1854; and from Dr. Giebel's "Fauna der Vorwelt" (Insekten und Spinnen), pp. 187, 393-426.

Agrilus stomphax.	Chrysomela Dunkeri.
„ cyllarus.	„ dubia.
„ cyllabacus.	„ ignota.
Elaterium pronaeus.	„ tertiaria.
„ triopas.	Coccinella Neptuni.
„ barypus.	„ Perses.
„ Oweni.	Prionus antiquus.
„ Morrisi.	Lamia Schroeteri.
Tentyridium peleus.	Curculionites Syrichthys.
Crypticus Ungeri.	„ Westwoodi.
Helopium agabus.	„ tuberculatus.
Diaperidium mithrax.	„ marginatus.

ORTHOPTERA.

Gryllidium Oweni.	Rithma Murchisoni.
Mantis ? (undetermined).	„ Morrisi.
Blattina anceps.	„ antiqua.
„ recta.	„ ramificata.
Rithma Westwoodi.	Nethania Molossus.
„ Purbecoensis.	Blatta elongata.

NEUROPTERA.

Ela brephos.	Chimarrha Pytho.
Elcana tessellata.	Libellula agrias.
„ Beyrichi.	Libellulium Kaupi.
Abia Sipylus.	Estemoa Bubas.
„ duplicata.	Phryganidæ.
Hagla ignota.	

HEMIPTERA.

Neurocoris ?	Cercopis Telesporus.
Lygæites Dallasi.	„ Schæfferi.
„ furcatus.	„ Signoreti.
„ priscus.	Cercopidium Hahni.
Cicada psocus.	„ trigonale.
Cercopis Mimas.	

DIPTERA.

Simulidium priscum.	Corethrium pertinax.
Thiras Westwoodi.	Campylomyza grandæva.

HYMENOPTERA.

Ponera Brodieri.	Myrmica Heeri.

LEPIDOPTERA ?

Cyllonium Boisduvalianum.	Cyllonium Hewitsonianum.

Professor Westwood[1] has specifically named and also figured the

[1] See "Quart. Journ. Geol. Soc.," 1854, Vol. x., pp. 393-397.

following species from the Middle and Lower Purbecks of Dorset :—

Elaterium pronæus.
Helopium agabus.
Curculium Syrichthus.
Formicium Brodiei.
Buprestium Woodlei.
" teleas.
Blapsium Egertoni.
Harpalidium anactus.
Tentyridium peleus.
Corethrium pertinax.
Cercopidium mimas.
" telesphorus.
Libellulium agrias.
Œschnidium bubas.
Cicadellium dipsas.
" psocus.
Buprestium gorgus.
Diaperidium mithrax.
Simulidium priscum.
Termitidium ignotum.
Panorpidium tessellatum.
Cecidomium grandævum.
Blattidium molossus.
Elaterium triopas.
" barypus.
Buprestium stygnus.
" vulgus.
" dardanus.
Agrilium stygnus.
" stomphax.
" cyllarus.
" cyllabacus.
Ctenicerium blissus.
" hylastes.
Harpalidium nothrus.
Telephorium abgarus.
Buprestium bolbus.
Panorpidium tessellatum.
Cimicidium Dallasi.
Raphidium brephos.
Cyllonium Boisduvalianum.
" Hewitsonianum.
Gryllidium Oweni.
Libellulium Kaupii.
Carabidium dejeananum.
Cercopidium Hahnii.
" Schæfferi.
" Signoreti.
Nepidium Stolones.
Myrmicium Heeri.
Blattidium nogaus.
" achelous.
" symyrus.
Phryganeidium Pytho.
Agronidium Ætna.

List of insect remains, chiefly from the Lower Purbecks of Wilts and Bucks, extracted from Brodie's "Fossil Insects," and his paper on "The Distribution and Correlation of Fossil Insects" :—

(1.) Coleoptera.

Carabidæ.
Staphylinidæ.
Cerylon.
Helophorus.
Cyphon.
Rhyncophora.
Buprestidæ.
Tenebrionidæ.
Harpalidæ.
Colymbetes.
Elateridæ.
Curculionidæ.
Limnius.
Cantharidæ.
Hydrophilidæ.
Helophoridæ.

(2.) Orthoptera.

Acheta.
Blatta.

(3.) Neuroptera.

Leptoceridæ.
Phryganeidæ.
Termes.
Corydalis.
Œschna.
Lindeniæ.
Libellula.

(4.) Hemiptera.

Kleidocerys.
Cixius?
Ricania.
Asiraca.
Aphis.
Cimicidæ.
Cercopis.
Cicada.
Delphax.
Velia.
Hydrometra.
Molobius.

(5.) Diptera.

Simulium.
Platyura.
Tanypus.
Empidæ.
Sciophila.
Macrocera.
Chironomi.
Culex.
Chironomus.
Rhyphus.
Macropeza.
Tipulidæ.

From the Lower Purbecks of the Vale of Wardour, in Wiltshire:—

Coleoptera.[1]

Elmis Brodiei.
Helophorus antiquus.
„ Brodiei.
Hydrobius Purbeccensis.
Hydrophilus Westwoodi.
„ Brodiei.
Carabus elongatus.
Camptodontus Angliæ.
Cymindis antiqua.
Philonthus Kneri.
Prognatha crassa.
Elater Purbeccensis.
„ Werneri.
Cyphon vetustus.
Meloe Hoernesi.
Tenebrio rugoso-striatus.
Cerylon striatum.
Hypera antiqua.

Orthoptera.

Gryllus Sedgwicki.
Blattina Stricklandi.
„ similis.
„ recta.
Elisama Kneri.
Elisama minor.
Blatta pinna.
„ Kollari
„ Ungeri.
„ pluma.

Neuroptera.

Bittacus dubius.
Panorpa gracilis.
Orthophlebia bifurcata.
, minuta.
Zalmona Brodiei.
Æschna perampla.
Libellula petrificatus.
„ jurassica.
„ antiqua.
Termes grandævus.

[1] This list is compiled from Brodie's "Fossil Insects," his paper on the "Correlation of Fossil Insects," and Dr. Giebel's "Fauna der Vorwelt."

HEMIPTERA.

Hydrometra?	Asiraca Kengotti.
Cicada punctata.	Delphax pulcher.
Flata Haidingeri.	Cercopis lanceolata.
Ricania fulgens.	Aphis valdensis.
Cixia maculata.	„ plana.
Asiraca Egertoni.	„ dubia.

DIPTERA.

Remalia sphinx.	Adonia Fittoni.
Hasmona leo.	Chironomus extinctus.
Bria prisca.	„ arrogans.
Simulidium humidum.	Macropeza prisca.
Thimna defossa.	Asuba Brodiei.
Sama rustica.	Dara fossilis.

From Lower Purbecks (Ridgway Quarries, near Dorchester):—

Numerous elytra of Coleoptera
And a fragment of the wing of a Neuropterous insect.

From Purbeck (?) strata in the neighbourhood of Swindon, Wilts :—

Elytra of Coleoptera.

KIMMERIDGE CLAY.

From a block of Septaria in the Kimmeridge Clay, near Ringstead, Dorsetshire :—

Fragment of an elytron of a small beetle. [1]

MIDDLE OOLITE.

OXFORD CLAY.

From the Oxford Clay near Christian Malford :—

Supposed larva of an insect, possibly a *Libellula*.

LOWER OOLITE.

FOREST MARBLE.

From quarries at Farleigh, near Bath :—

Elytra of Coleoptera and small wings. [2]

GREAT OOLITE.

From the Eastern Moorlands of Yorkshire :—

Elytra of Coleoptera.

[1] "Quart. Journ. Geol. Soc.," 1853.
[2] Brodie's "Fossil Insects," p. 37.

STONESFIELD SLATE.

From the Stonesfield Slate, Stonesfield, Oxfordshire, and Sevenhampton and Eyeford, Gloucestershire:—

COLEOPTERA.[1]

Blapsidium Egertoni.	Blapsidæ? (Elytra f.)
Buprestidæ.	Prionus ooliticus (Brod.)
Curculionidæ.	Pimeliidæ?
Melolonthidium.	Chrysomelidæ?
Prionideum.	Coccinella? Wittsii.

NEUROPTERA.

Hemerobioides giganteus.	Libellulæ? (two wings of.)
Libellula Westwoodi.	

LEPIDOPTERA. ?

Palæontina oolitica.[2]	And wing of Lepidopterous? insect unnamed.[3]

LIAS.

List of Insects from the English Lias, extracted from the Rev. P. B. Brodie's[4] paper on "The Distribution and Correlation of Fossil Insects :—"

Insects.	*Locality.*	*Geological Horizon.*
		Upper Lias.
Libellula.	Dumbleton.	"
" (Heteroplebia) Brodiei.	"	"
Œschna.	"	"
Agrion.	"	"
Orthoptera.	"	"
Blattidæ.	"	"
Beetles of several genera.[5]	ditto. and Alderton.	Upper Lias.
Body of gigantic Libellula.	Strensham.	
Libellula.	Strensham.	Lower Lias.
Orthoplebia,	Wainlode, Forthampton, Bidford, Brown's wood, Strensham, Cracombe, and Somersetshire.	ditto.

[1] This list is compiled from Brodie's "Fossil Insects," and his paper on the "Correlation of Fossil Insects"

[2] P. oolitica (Butler), Stonesfield Slate. "Geol. Mag.,' Oct., 1874. Plate xix., figs. 4 and 5.

[3] Wing of supposed Lepidopterous insect, from Stonesfield Slate, Oxford, in the collection of J. Parker, Esq., of Oxford.

[4] "Proceedings of the Warwickshire Naturalists' and Archæologists' Field Club," 1874.

[5] This list is simply *extracted* from Mr. Brodie's before-mentioned paper. No attempt has been made to amend the arrangement, or to correct any but clerical errors.

Insects.	*Locality.*	*Geological Horizon.*
Œschna.	Bidford.	Lower Lias.
Chauliodes.	Brown's wood, Hasfield, Strensham, Binton, Copt Heath, Knowle.	ditto.
Ephemera.	Strensham, Brown's wood, Binton, Westbury.	ditto.
Myrmeleon ?	Binton.	ditto.
Trichopterous.	Grafton.	ditto.
Libellulideous wings, chiefly,	Strensham, Brokeridge, Binton, Wilmcote, Grafton, Brown's wood, Barrow on Soar.	ditto.
Hemerobius (wing of), most nearly allied to the recent Polystæchetes. (Scudder).		ditto.
	COLEOPTERA.	
Carabidæ.	Apperley, Brockeridge.	ditto.
Harpalideous Carabidæ.	Binton, Wilmcote.	ditto.
Buprestidæ or Elateridæ.	Vale of Gloster near Churchdown.	Lima beds.
Elytra of two or three other genera.	The Leigh.	Lima shales.
Buprestidæ or Elateridæ.	Wainlode, Apperley, Brockeridge	Lower Lias.
Elateridæ.	Wainlode, Apperley, Westbury.	ditto.
Buprestidæ.	Strensham.	ditto.
Gyrinus.	Forthampton.	ditto.
Ditto, like a foreign species.	Norton.	ditto.
Pentatomidæ (body of).		
Telephoridæ.	Forthampton, Wainlode, Brown's wood.	ditto.
Curculionidæ or Chrysomelidæ.	Apperley, Hasfield.	ditto.
Chrysomelidæ.	Forthampton.	ditto.
Aquatic Beetle.	Wainlode.	ditto.
Laccophilus (Dyticidæ).	Hasfield.	ditto.
Melolontha.	Cracombe.	ditto.
Trogulus.	Strensham.	ditto.
Tettigonia (Pupa of).	Wainlode.	ditto.
Elater or Buprestis. (large entire beetle.)	Strensham.	ditto.
Elytra of several species.	Westbury	ditto.
Elytra of two species of Coleoptera.	Hotham, Yorkshire.	ditto.
Under wings of Beetles.		ditto.
Upper surface of anal segment of a Beetle.	Hotham.	ditto.

ORTHOPTERA.

Insects.	*Locality.*	*Geological Horizon.*
Species of (Orthoptera).	Grafton.	Lower Lias.
Gryllidæ.	Wilmcote, Binton, Apperley, Grafton, Forthampton.	ditto.
Blattidæ.	Wainlode, Strensham.	ditto.
Locusta ? (under wing.)	Strensham.	ditto.
HEMIPTERA		
Cicada.	Hasfield.	ditto.
Belostoma.	Wainlode.	ditto.
Hemielytra of a Cicada like Meloe.	Forthampton, Apperley, Wainlode.	ditto.
Cimex.	Strensham.	ditto.
Gigantic Homoptera.	Binton,	ditto.
Homopterous larva.	Strensham.	ditto.
DIPTERA.		
Asilus.	Forthampton.	ditto.
Tipula (entire insect head, antennæ and wings.)	Strensham.	ditto.
Diptera (entire), undetermined.	Wainlode, Apperley.	ditto.

List of insect remains from the English[1] Lias and Rhætics compiled from Dr. Giebel's "Fauna der Vorwelt," &c.:—

COLEOPTERA.

Melolontha greithana.
Berosus liasinus.
Buprestites bractoides.
Gyrinus natans.
,, dubius.
Laccophilus aquaticus.
Harpalus Heeri.
,, liasinus.
,, Schlotheimi.
Ancylochira liasina.
Elater vetustus.
,, socius.
,, Neptuni.
,, Redtenbacheri.
,, angulatus.
,, varius.
Telephorus Haueri.
Chrysomela Andraei.
,, liasina.

NEUROPTERA.

Elcana Beyrichi.
Orthoplebia longissima.
,, communis.
,, parallela.
,, similis.
,, intermedia.
,, lata.
Orthoplebia furcata.
,, liasina.
Hemerobius Higginsi.
Hagla gracilis.
,, similis.
,, deleta.
,, ignota.

[1] Wainlode Cliff, Apperley, Hasfield, Tewksbury, Forthampton, and other parts of Gloucestershire, Worcestershire, Warwickshire, Somersetshire Monmouthshire, and Yorkshire.

Diastatomma liasina.
Libellula Brodiei.
" Hopei.
Heterophlebia dislocata.
Heterophlebia Buckmanni.
" Westwoodi.
Rapha liasina.
Chauliodites minor.

ORTHOPTERA.

Akicera Heeri.
" Frauenfeldi.
Blattina liassina.
" incompleta.

HEMIPTERA.

Pachymerus Zucholdi.
Belostomum liasinum.
Cicada Murchisoni.

DIPTERA ?

Asilus ignotus ?

CONTINENT OF EUROPE.

CRETACEOUS.

From beds of sand in the neighbourhood of Aix la Chapelle:—

Several species of Coleoptera, chiefly Curculionidæ, and Carabidæ. [1]

From the Chalk Marl of the Mountain of St. Catherine, near Rouen :—

Elytra of Coleoptera. [2]

From the Gault[3] of Lottinghem, Pas-de-Calais :—

Traces of Coleoptera, supposed to belong to the genus *Hylesinus* of the *Scolytidæ*.

From the Upper and Lower Greensands of Saxony:—

Traces of Longicorn Beetles, supposed to be *Cerambycidæ*.

UPPER OOLITE.

SOLENHOFEN SLATE.

List of genera of insects from Solenhofen and Pappenheim, compiled from Bronn's "Lethæa Geognostica," Vol. i, p. 210 (1835-1837).

COLEOPTERA.

Cerambyx
Hydrophilus.

NEUROPTERA.

Libellula.
Agrion.
Œschna.
Myrmeleon.

HYMENOPTERA.

Sirex.
Ichneumon.

LEPIDOPTERA.

Sphinx ?

List of the fossil insects from Solenhofen, described by Prof.

1 "Lyell's Elements," 6th edit., p. 331.
2 "Traité élémentaire de Paléontologie," Vol. iv, pp. 95 and 102.
3 "Ann. Soc. Ent. de France." 1876, p. 217.

Germar, in the "Nova Acta" of the Academy of Leopold Charles of Austria, 1839, xix, 2 s, 189-222.

Locusta speciosa.	Sciara prisca.
„ priscus.	Æschina Munsteri.
Chresmoda obscura.	„ gigantea.
Ditomoptera dubia.	Libellula longialata.
Belostomum elongatum.	Agrion Latreillei.
Nepa primordialis.	Scarabæides deperditus.
Pygolampis gigantea.	Ricania hospes.
Cerambycinus dubius.	Musca lithophila.
Apiaria antiqua.	

Fossil insects from Solenhofen, enumerated by Dr. Giebel, in his "Fauna der Vorwelt" (Insecten und Spinnen):—

COLEOPTERA.

Scarabæides deperditus.	Mesosa Germari.

ORTHOPTERA.

Phaneroptera Germari.	Chresmoda obscura.
Locusta prisca.	Decticus speciosus.

NEUROPTERA.

Agrion vetustum.	Æschna longialata.
Diastatomma Münsteri.	„ gigantea.
Æschna Charpentieri.	„ intermedia.
„ Schmideli.	„ Buchi.
„ antiqua.	„ bavarica.
„ Parkinsoni.	Libellula Koehleri.

HYMENOPTERA.

Apiaria antiqua.

HEMIPTERA.

Pygolampis gigantea.	Belostemum elongatum.
Nepa primordialis.	Ricania hospes.

DIPTERA.

Musca lithophila.	Sciara prisca.

The following list of fossil insects from Solenhofen includes (to the best of my knowledge) every species which has, up to the present date, been described by Professor Germar,[1] Count Münster,[2] Herr Carl von Heyden,[3] Dr. Giebel,[4] Dr. Hagen,[5] and Herr Weyenbergh, jun.[6]

1 "Nova. Acta." Acad. Nat. Cur. T. xix., 189-222. 1839.

2 "Beiträge," T. v. 1841.

3 "Palæontographica," Vol i., pp. 99-101. 1851.

4 "Fauna der Vorwelt," Vol. ii. 1856. "Zur Fauna des Lithographischen Schiefers von Solenhofen." 1857.

5 "Enumeration des Odonates Fossiles d'Europe." "Revue des Odonates," by E. de Selys-Longchamps, pp. 356-364. 1850. "Palæontographica," Vol. x., pp. 96-145. 1861-1863, and Vol. xv., pp. 59-96, 1865-1868.

6 "Archives du Musée Teyler," Vol. ii., pp. 247-294. 1869. Vol. iii., pp. 234-240, and "Period. Zool. Arg." t. i. (See also "Catalogue systématique de la Collection Paléontologique du Musée Teyler," 1876, by Dr. Winkler.

COLEOPTERA.

Mesosa Germari.
Chrysobothrys veterana.
Ditomoptera dubia.
Carabicina decipiens.
Scarabæides deperditus.
Carabus Winkleri.
Hydroporus petrefractus.
Gyrinus (?) Jurassicus.
Silpha tennilythris.
Scaphidium Hageni.
Hister relictus.
Meloe Bavaricus.
Oryctes Pluto.
Cetonia (?) defossa.
Buprestis lapidelythris.
Lacon petrosum.
Elater Teyleri.
„ Costeri.
„ grossus.
Tenebrio innominatus.
Anisorhynchus (?) lapideus.
Saperdides cristallosus.
Leptura primigenia.
Cryptocephalus antiquus.
„ mesozoicus.
Chrysomela lithographica.
„ rara.
Cassida æquivoca.
Coccinella Heydeni.

NEUROPTERA.

Isophlebia Aspasia.
„ Helle.
Stenophebia æqualis.
Heterophlebia dislocata.
„ Amphitrite.
„ Phryne.
„ eximia.
„ casta.
Euphœa multinervis.
„ filosa.
„ areolata.
„ longiventris.
Agrion hecticum.
„ exhaustum.
„ Eichstättense.
„ vetustum.
Anax Charpentieri.
Petalia longialata.
Petalura gigantea.
„ latialata.
„ eximia.
„ intermedia.
„ Münsteri.
Petalura varia.
„ differenz.
Libellula (?) densa.
„ abscissa.
„ nævia.
„ valga.
Termes heros.
„ lithophilus.
„ fossilis.
Ephemera cellulosa.
„ procera.
„ mortua.
„ prisca.
„ Meyeri.
„ deposita.
Hemerobius priscus.
„ fossilis.
Chrysopa protognea.
„ Solenhofensis.
Apochrysa excelsa.
Nymphes fossilis.
Myrmeleon extinctus.
Corydalis vetusta.

ORTHOPTERA.

Forficularia problematica.
Gryllites dubius.
Phaneroptera Germari.
„ striata.
Chresmoda obscura.
Blattaria Dunckeri.
Locusta prisca.
„ speciosa.
„ amanda.
Blabera invita.
Achita quærula.

HEMIPTERA.

Velia cornuta.	Nepa primordialis.
Naucoris lapidarius.	Propygolampis Bronni.
Corixa mortua.	Pygolampis gigantea.
Belostomum Hartingi.	Actea sphinx.
„ elongatum.	(Hagenia ?) Schroeteri.
Ricania gigas.	Cicada Proserpina.
„ hospes.	„ prisca.
Lystra Vollenhoveni.	„ gigantea.

DIPTERA.

Asilicus lithophilus.	Empidia Wulpi.
Musca lithophila.	Cheilosia dubia.
Tipularia Teyleri.	

HYMENOPTERA.

Apiaria antiqua.	Anomalon palæon.
„ lapidea.	Bombus ? conservatus.
„ veterana.	

LEPIDOPTERA.

Sphinx Snelleni.[1]	Pseudosirex Darwini.[2]

LIAS.

List of fossil insects from the Lower Marls of the Lias at Schambelen, in the Canton of Aargau, in Switzerland, compiled from Dr. Heer's "Urwelt der Schweiz" :—

COLEOPTERA.

	Species.		Species
Carabidæ	... 11	Buprestidæ	... 33
Gyrinidæ	... 6	Elateridæ	... 10
Nitidulidæ	... 7	Telephoridæ	... 3
Peltidæ	... 4	Cistelidæ	... 1
Cryptophagidæ	... 2	Rhynchophora	... 7
Lathridiadæ	... 1	Chrysomelinæ	... 3
Mycetophagidæ	... 1	Doubtful forms	... 6
Byrrhidæ	... 5	Total number of species of Coleoptera	116
Hydrophilidæ	... 15		
Aphodiidæ	... 1		

ORTHOPTERA.

Blattina formosa.	Acridiites deperditus.
„ angustata.	„ liasinus.
„ media.	Baseopis forficulina.
Gomphocerites Bucklandi.	

[1] From the figure of this insect, in Herr Weyenbergh's paper, it undoubtedly belongs to the Sphingidæ.

[2] "Arch. Teyl." t. iii., p. 279, and "Period. Zoo. Arg." t. i., pl. 3.

NEUROPTERA.

Clathrotermes signatus.
Calotermes maculatus.
„ plagiatus.
Calotermes troglodytes.
„ obtectus.
Æschna Hageni.

HEMIPTERA.

Protocoris insignis.
„ ovalis.
Cyclocoris pinguis, and other species of Coreodea.
Cicadellinæ (3 species.)
Cercopidium morio.
„ minutum.

HYMENOPTERA ? [1]

Palæomyrmex prodromus.

RHÆTICS.

List of fossil insects from Schonen, Sweden [2] :—

COLEOPTERA.

Hydrophilites Nathorsti.
Buprestites rugulosus.
Curculionites parvulus.
„ Carlsoni.
Elytridium angelini.
Elytridium lævigatum.
Carabites deplanatus, and fragments of the abdomen of a beetle.

TRIAS.

From Trebitz, Salzmunde, and Vadutz, Switzerland:—

COLEOPTERA.

Glaphyroptera pterophylli.
Curculionites prodromus.
Chrysomelites Rothenbachi.

NEUROPTERA.

Chauliodites Picteti.
„ Zinckeni.
Chauliodites Helveticus.

ORTHOPTERA.

Legnophora Girardi.

AMERICA. [3]

TRIAS.

From the Triassic Rocks of the Connecticut Valley :—

Coleoptera, one specimen unnamed, and traces of various *Insecta* and *Myriopoda*.

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[1] No traces of insects of this Order have been elsewhere recorded from rocks of this age, even in those localities in which insect remains have been found in abundance, and it is highly improbable that the Order had appeared at so early a period.

[2] See "Ueber einige Insektenreste aus der raetischen Formation Schonens," Aftryck ur Geol. Föreningens i Stockholm Förhandl., 1878, No. 49 (Bd. iv, No 7), and see *ante*, p. 136.

[3] See *ante*, p. 137.

ORDINARY MEETING.

MARCH 7TH, 1879.

Prof. T. RUPERT JONES, F.R.S., F.G.S., President, in the Chair.

The Donations to the Library received since the previous meeting were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association :—

M. Charles Brogniart, M.Ent.S.Lond., Hon. Memb. Manches. Geol. Soc.; Rev. David Fotheringham; Oswald Fitch, Esq., F.G.S.; Ernest Husey, Esq.; James R. McGregor, Esq.; E. H. Manders, Esq., B.A.; William Melles, Esq., F.Z.S.; John Dennis Paul, Esq., F.G.S.; John Reid, Esq., F.Z.S.; R. D. Roberts, Esq., M.A.; and Keith D. Young, Esq.

The following Paper was read :—

ON THE INSECT FAUNA OF THE PALÆOZOIC PERIOD, AND THE BRITISH AND FOREIGN FORMATIONS OF THAT PERIOD IN WHICH INSECT REMAINS HAVE BEEN DETECTED.

BY HERBERT GOSS, F.L.S., F.G.S.

VISIT TO THE BRITISH MUSEUM.

SATURDAY, MARCH 15th, 1879.

Director :—Prof. H. G. SEELEY, F.G.S.

The Director on this occasion gave a demonstration on the Dinosauria, the subject of Professor Seeley's Paper read before the Association, May 2nd, see page 175.

VISIT TO THE BRITISH MUSEUM.

SATURDAY, MARCH 29th, 1879.

Director :—DR. HENRY WOODWARD, F.R.S.

Members assembled in the Entrance Hall of the Museum and thence proceeded to the galleries, where Dr. Woodward gave a demonstration on the Cephalopoda, illustrating his remarks by the numerous and beautiful specimens around him.

ORDINARY MEETING.

APRIL 4TH, 1875.

Prof. T. RUPERT JONES, F.R.S., F.G.S., President, in the Chair.

The Donations to the Library received since the previous meeting were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association :—

Edward Lindhamer, Esq.; and A. D. Maclaren, Esq.

The following Papers were read :—

1. ON THE FOSSIL CORALS OBTAINED FROM THE OOLITE OF THE RAILWAY CUTTINGS NEAR HOOK NORTON, OXFORDSHIRE.

By ROBERT F. TOMES, F.G S.

In the very interesting paper on the Geology of the Eastern portion of the Banbury and Cheltenham Railway, by Mr. T. Beesley, published in the Proceedings of the Geologists' Association, is a very ample list of fossils obtained from cuttings through the Great and Inferior Oolite, near to Hook Norton, Oxfordshire. In this list are several species of coral, and the specimens having been submitted to me by Mr. Beesley for identification, form the basis for the investigation, of which the present communication is the result, which may, therefore, be regarded as supplementary to his paper.

But besides these specimens, collections from the same localities have been forwarded to me by Mr. E. A. Walford, of Banbury, and Mr. James Windowes, of Chipping Norton; and during the past year I paid a personal visit to the localities and made a small collection of Great Oolite species, which I had the advantage of observing *in situ*. For their position in the section, as well as an account of the bed in which they occur, I must refer to Mr. Beesley's paper. (Proc. Geol. Assoc., Vol. v, p. 165.)

I have endeavoured to make the list of species more ample, and this communication more complete, by including some species

from other localities in that part of Oxfordshire which lies at no great distance from the towns of Banbury and Chipping Norton.

Although several localities in Oxfordshire have long been celebrated for their abundance of fossil oolitic corals, as for instance Cumnor and Headington, yet the district here indicated is comparatively a new one, and furnishes us with species from the Great and Inferior Oolite instead of with Coral Rag species. It does indeed in this respect compare rather with the oolite of Gloucestershire, than with that of other Oxfordshire localities which are well known for the ample development of the Coralline Oolite.

There is, however, one locality here mentioned to which it is essential that I should call especial attention—Garsington. A small collection of corals purporting to be from that place, and further stated to have been collected from the "Coralline Oolite," has been placed in my hands. The greater part of the collection consists of specimens of *Isastræa limitata*, and in their mineral condition, as well as in their present state of preservation and weathering, they so absolutely resemble the specimens taken from the surface of the ploughed fields at Glympton and Steeple Barton, that I do not doubt for a moment that they appertain to the Great Oolite and not to the Coral Rag. One specimen from this collection is a *Cyathophora*, a genus now for the first time recorded as occurring in this country, for the species heretofore referred to it by MM. Edwards and Haime, have been shown by Dr. de Fromentel to appertain to the genus *Cryptocœnia* of D'Orbigny.

All the species of corals here enumerated come under the Sub-Orders, *Zoantharia aporosa*, *Zoantharia porosa*, and *Zoantharia tabulata.*

Of the first of these, two families are represented—the *Astræidæ* and the *Fungidæ ;* of the second, one genus only appears, *Microsolina ;* and of the third, the genus *Cyathophora* only has been hitherto recognised.

INFERIOR OOLITE.

ZOANTHARIA APOROSA.

Family—ASTRÆIDÆ.

1. MONTLIVALTIA TROCHOIDES. Edw. and Haime, Monog: Astræides. Ann. des Sci. Nat., S. 3, V. x., p. 299. 1848.

A considerable number of well preserved specimens of this species, some of them of considerable size, have been obtained by

Mr. James Windowes, of Chipping Norton, from a place near that town called Sargrove Wood. In answer to an enquiry I made respecting the position of this coral in the Inferior Oolite, Mr. Windowes writes: "We pick up the *Montlivaltias* in a ploughed field; every time the field is ploughed more specimens are turned up, so they must occur near the surface. There are no pits anywhere near, so it is impossible to say with certainty how thick the Inferior Oolite is, but I should say it is quite fifteen feet from the surface to the top of the Upper Lias." The only other corals found associated with the *Montlivaltias*, as I learn from Mr. Windowes, are a few bad and altogether imperfect examples of *Convexastræa Waltoni*.

2. Montlivaltia lens. Edw. and Haime. Brit. Fos. Cor., p. 133, Pl. xxvi., fig. 7 & 8. 1851.

I have for many years been very familiar with this species from several places in Oxfordshire and Gloucestershire, and until very recently believed it to be peculiar to the beds of the Inferior Oolite near their junction with the Upper Lias. From near the bottom of the Inferior Oolite at Tadmarton, near Banbury, specimens have been taken by Mr. Beesley, Mr. Walford, and myself. At that locality it appears to be pretty abundant; and its even greater abundance in this zone, where exposed, all through Gloucestershire, led me to regard it as a characteristic fossil and confined to that stratum. But that it passes upwards and occurs in the Great Oolite is now evident, for I have been favoured with the loan of a specimen by Mr. Walford, taken by him from the *Astarte angulata* beds of the Great Oolite in the railway cutting at Rollwright-Pesthouse, on the Banbury and Cheltenham Railway.

3. Thecosmilia Wrighti, Duncan. Supp. Brit. Cor., Part III., p. 17, Pl. 5, fig. 1—5. 1872.

A specimen of this species has been obtained from the *Ammonites Murchisoni* beds of the Inferior Oolite at Coombe Hill, near Great Barford, Oxfordshire, by Mr. E. A. Walford, and kindly forwarded by him for my use. It is obviously identical with specimens from the Inferior Oolite of Gloucestershire.

4. Isastræa serialis. Edw. and Haime. Brit. Fos. Cor., p. 116, Pl. xxiv., fig. 2—18. 1851.

Of this well marked species several examples have been obtained

from the railway cutting near Hook Norton, where they were associated with *Ammonites Murchisoni*.

5. ISASTRÆA LIMITATA. Edw. and Haime. Polyp. Palæon., p. 103. 1851.

Astræa limitata. Lamouroux in Mechelin. Icon. Zoop., p. 225 Pl. 54, fig. 10. 1840—7.

The specific name of this species was given to it by M. Lamaroux, but appears first in an extract from his MS. notes in Mechelin's "Iconographic Zoophytologique," which was published in 1840—7. Most likely, however, the figure given in that work was taken from a specimen in Mechelin's own collection, as we learn from him that both M. Deslongchamps and himself possessed specimens. The plate on which this species is figured is headed Forest Marble of Luc, Ranville (Calvados), but in the letter-press he furnishes no information respecting its stratigraphical position.

MM. Edwards and Haime described it in their "History of British Fossil Corals" from specimens obtained from the Great Oolite near Bath, but in their "Histoire Naturelle des Corallaires" we are furnished with the following information only:—"Groupe oolitique inferior, Luc, Ranville, Langrune, environs of Bath; Marquises, Rumigny (Ardennes), Harancourt près de Sedan." This would seem by no means to restrict this species to the Great Oolite.

McCoy, in the "Annals and Magazine of Natural History," for 1848, mentions it as occurring in the Inferior Oolite at Leckhampton, near Cheltenham, and Professor Morris, in the second edition, of his "Catalogue of British Fossils," records also its occurrence at the same place.

It would appear from these authorities that the *Isastræa limitata* is not strictly confined to that division of the oolite to which it was at one time assigned by English Paleontologists, but that it is like some other species mentioned in this paper, common to both the Inferior and Great Oolite. This view is fully borne out by its occurrence in the Inferior Oolite of the railway cutting near Hook Norton, from which place specimens have been obtained by Mr. Beesley, Mr. James Windowes, and myself. These examples answer very exactly to the figure given by Mechelin. They have a flattened and expanded form, their upper surface presents very little convexity, and their preservation is so complete that when

broken through, and the broken surfaces weathered, the internal structure is so beautifully shown that even the delicate ornamentation of the sides of the septa is distinctly visible.

6. CLAUSASTRÆA CONYBEARI. Edw. and Haime. sp.

Isastræa Conybeari. Edw. and Haime. Brit. Fos. Cor, p. 131, Pl. 22, fig. 4.

By the kindness of Mr. Beesley I have been enabled to make a very careful examination of several examples of this species, which has resulted in its removal from the genus *Isastræa.*

Although recorded only as a Great Oolite species by Edwards and Haime from a single ill-preserved specimen obtained by Mr. Pratt, from Comb Down, near Bath, there can be no doubt that it is the same species which occurs, and by no means rarely, in the Inferior Oolite of several localities in Oxfordshire.

As the description given by Edwards and Haime of this remarkable species was taken from a specimen which was so ill-preserved that probably it did not show the characters properly, it will be desirable that I should here add such particulars as I have observed in a series of well-preserved specimens, and the more so as they reveal characters not suspected by those celebrated zoophytologists.

The general form of the corallum is rudely lenticular, the upper and under surfaces having about the same degree of convexity. There is a complete basal wall or plate, and well developed and regular costæ, with numerous but not strongly marked inter-costal dissepiments. The epitheca is irregular and confined to concentric folds.

The peculiar form of the calices, mentioned by Edwards and Haime, is observable in all the Hook Norton specimens, and in some others from Swerford in the same county, but they are not divided by walls as in *Isastræa*, the whole of the mural regions being filled up by large, well developed, and dome-shaped dissepiments, which in vertical sections are seen to fill up the whole of the interseptal loculi.

7. CRYPTOCŒNIA LUCIENSIS.

Cyathophora Luciensis. Edw. and Haime. Brit. Fos. Cor., p. 108 Pl. 21, fig. 5. 1851.

A single example of a *Cryptocœnia* in Mr. Beesley's collection, which I refer to in this species, was obtained by him from the Inferior

Oolite at Great Tew, Oxfordshire. It is in an indifferent state of preservation, but may with tolerable certainty be referred to *C. Luciensis*, notwithstanding that it has not hitherto been recorded as occurring in the Inferior Oolite.

Family—FUNGIDÆ.

Thamnastræa Defranciana. Edw. and Haime. Polyp. Terr. Palæon. p. 110. 1851.

Astræa Defranciana. Mecholin. Icon. Zooph., p. 9, Pl. ii., fig. 1. 1840.

I have examined a specimen of this species from the railway cutting at Hook Norton, taken by Mr. E. A. Walford. It does not differ in any important degree from the flattened specimens which occur pretty commonly in the Inferior Oolite near Cheltenham, excepting in having the basal plate naked and costulated.

THAMNASTRÆA. (?)

Several examples of a species of *Thamnastræa*, having characters which approximate it in some degree to *T. concinna*, have been obtained from the Inferior Oolite of Hook Norton, which differ nevertheless from that species in some very important particulars. At present I have not examined specimens in a good state of preservation, and prefer to pass this species over without further remark, until better examples are obtained.

GREAT OOLITE.

ZOANTHARIA APOROSA.

Family—ASTRÆIDÆ.

MONTLIVALTIA LENS. I have already mentioned this species as occurring in the Inferior Oolite near Banbury, and in the Great Oolite near Rollwright, and I only insert it here to fill up the list of Great Oolite species.

CALAMOPHYLLIA RADIATA. Edw. and Haime, Monog. Polyp. Terr. Palæon. p. 81. 1851.

Eunomia radiata, *Lamouroux*, *Expos. Myth.* p. 83, Pl. 81, figs. 10—11. 1821.

I have collected specimens from the Great Oolite in the Hook Norton cutting, in the summer of last year, and had previously obtained some from Epwell, a village between Banbury and Brailes.

CLADOPHYLLIA BABEANA. Edw. and Haime, Polyp. Palæon., p. 81. 1850.

Eunomia Babeana. D'Orbig. Prod. Palæont., p. 292. 1850.

I have obtained examples of this species also from Epwell, and from Broughton, near Banbury.

ISASTRÆA LIMITATA. Edw. and Haime, Polyp. Palæon., p. 103. 1851.

Astræa limitata. Lamouroux, in Michlen. Icon. Zoop., p. 225, Pl. liv., fig. 10. 1840-7.

This species occurs at several localities in Oxfordshire : in the railway cutting near Hook Norton; at Glympton, near Woodstock; near Stonesfield; and near to Burford. The late Mr. Ch. Faulkner, of Deddington, Oxfordshire, gathered a great many specimens from the surface of a ploughed field at Glympton, and favoured me with a very interesting series, and the following statement of their occurrence :—

" These corals are found in abundance in a ploughed field close to the village of Glympton, near Woodstock. They are the same as Dr. Plott has described and figured in his 'Natural History of Oxfordshire,' but he mentions them as being found in the fields about Steeple Barton. This is a village not far from Glympton."

At first sight examples from the Great Oolite might easily be regarded as distinct from those from the Inferior Oolite, but a very careful examination of many specimens has convinced me that they are identical. Whenever the semi-dendroid or gibbous specimens from the Great Oolite assume in any part of the corallum the flattened form observable in those from the Inferior Oolite, the calices assume also the character of those of Inferior Oolite specimens.

ISASTRÆA MICROPHYLLA. n.s.

A single example of an *Isastræa*, having very small calices, was obtained by me from a quarry of Great Oolite at Epwell, near Brailes, where it was associated with *Cladophyllia Babeana*, *Anabacia orbulites*, and a small lenticular species of *Microsalina*.

The corallum is sub-dendroid, and rather higher than wide. The base is rather broad, with about twelve sub-equal branches which do not, however, betray any tendency to bifurcation. They are short, swollen, and nodular.

The calices are extremely small, irregular, pentagonal, and moderately deep.

The walls are rather thick.

The septa are very short, extending but a very little way into the visceral cavity. They are of nearly equal length, about 24 in number, straight, thin, and nearly smooth; they alternate on the top of the walls with those of contiguous calices.

In all the larger calices the septa are so nearly equal that the cycles cannot be determined, but in the younger ones the primary septa are easily made out, and are seen to meet, but not unite, in the bottom of the visceral cavity; the secondary are one half the length of the primary, and the tertiary ones are merely rudimentary.

Height of the corallum 2in. 3 lines.

Diameter of the calices about $\frac{3}{4}$ of a line.

Germination is abundant over the whole of the corallum, and quite as much so on the least prominent parts as at the ends of the branches, which would lead to the supposition that this species does not become more dendroid with greater age.

The general form of the corallum, the extremely small size of the calices, and the shortness and equality of the septa, will at once distinguish this species.

ISASTRÆA BEESLEYI. n.s.

Corallum almost sphærical, but a little depressed. Base small, a little convex, or nearly horizontal. Costæ distinct; epitheca rudimentary or wanting.

Calicular surface very convex, regular, and constituting three-fourths of the corallum. Calices pentagonal or hexagonal, rather regular in size, and of moderate depth.

Walls strong, but their extreme edges thin.

Septa of medium thickness, straight, rather numerous, exsert, their margins papillated, but their sides nearly smooth. Nearly all are continuous with those of the contiguous calices. They are about 50 in number, and constitute four complete cycles and an imperfect one. The primary ones extend nearly to the centre of the visceral cavity, but leave a small fossula. They increase in thickness as they approach the centre. The secondary ones are nearly as long as the primary ones, and thicken a little at their inner ends. The tertiary cycle is scarcely half the length of the second, and the fourth is half the length of the third.

Height of the corallum, about $2\frac{1}{2}$ inches. Diameter of the corallum about 3 inches. Diameter of the calices, $2\frac{1}{2}$ to $3\frac{1}{2}$ lines. Depth of the calices about 1 line.

The germination takes place at the angles of the calices.

Several examples of this species have been obtained from the Great Oolite of Oxfordshire. One of these, in the collection of Mr. Beesley, was obtained at Great Tew, and both Mr. James Windowes and myself have met with specimens in the railway cutting at Hook Norton.

LATIMEANDRA LOTHARINGA. E. de From. cat. polyp. de l'yonne. 1856.

Meandrina lotharinga. Mich. Icon. Zooph., p. 100, Pl. 22, fig. 2.

Two examples of a species of *Latimeandra*, with very narrow and much curved furrows, were taken by me from the Coral-zone in the railway cutting at Hook Norton, in 1878. They so closely resemble the *L. lotharinga* in all respects, excepting in not having a dendroid form, that I cannot regard them as referable to any other species. Michelin, who first described and figured the species, speaks of it as having a most unusual form for a *Meandrina*, in which genus he placed it.

My specimens have an irregular oblong form, with a convex and gibbous upper surface, and a rugged more or less concave base, showing the characteristic costulated wall. The costæ are numerous and well marked; the calicular furrows are rather short, very much curved, irregular, and rather shallow, and on some parts of the corallum they are either in twos or single.

Diameter of the calices about $1\frac{1}{2}$ lines.

Hitherto this species has been recorded as occurring in the Coral Rag only, but we may confidently expect, after having noted the continuance of species from the Inferior Oolite into the Great Oolite, that other species will be found to be common to the latter and to the Coral Rag.

The difference in form of this species when from the Coral Rag of the Continent and the Great Oolite of this country, does not appear to me to be of much specific importance, for I observe in the most amorphous coralline forms from the Great Oolite a strong tendency to assume a dendroid form. This is more especially the case with the *Isastræa limitata*, and it would be easy out of a considerable series from Hook Norton and Glympton to select

examples which, having been at first encrusting and foliaceous, had afterwards become dendroid.

CRYPTOCÆNIA INSIGNIS.

Cyathophora insignis. Duncan Supp. Brit. Fos. Cor., Part III, p. 14, Pl. i., fig. 9. 1872.

Aspecimen of this species was given to me some years since by the late Charles Faulkner, Esq., ofDeddington, which was obtained at Glympton, and I have another which is said to have been obtained from Garsington.

CRYPTOCÆNIA PRATTI.

Cyathophora Pratti. Edw. and Haime, Brit. Fos. Cor., p. 108, Pl. xxi., fig. 3. 1851.

Two specimens of this coral have been obtained by Mr. Walford; one from the Great Oolite near Stonesfield, and the others "from rifts in the top of Inferior Oolite at Hook Norton." I have also received a speeimen collected at the latter place by Mr. James Windowes.

CRYPTOCÆNIA LUCIENSIS.

Cyathophora luciensis. Edw. and Haime, Brit. Fos. Cor., p. 108, Pl. 21, fig. 5. 1851.

Through the kindness of Mr. James Windowes, I have examined a specimen of this species, obtained from the Great Oolite of the railway cutting at Hook Norton. It is rather remarkable for its dendroid form, and I was at first disposed to regard it as a distinct species, but in all its details it closely resembles specimens of *C. Luciensis*, to which species I therefore refer it.

CRYPTOCÆNIA HAIMEI. n.s.

A portion of a dendroid species of *Cryptocœnia* was obtained by myself some years since from a quarry of Great Oolite near Burford, which, from the small size of the calices, and their nearness to each other, I regard as a new species.

Corallum dendroid, with the ends of the branches clavate.

Calices very small and crowded.

Septa consisting of two cycles; the primary ones long, and extending nearly to the centre of the calice; the secondary ones not quite half the length of the primary.

Costæ broad and short.

Diameter of the calices $\frac{3}{4}$ of a line.

The calices of this species are so small and crowded that there is very little space for the development of costæ; indeed, where growth was proceeding most rapidly they interfere with each other, and are more or less angular, as in the genus *Isastræa*.

Unlike so many corals from the Great Oolite, this specimen, when cut and polished, shows the internal structure, and the tabulæ forming the succession floors of the visceral cavity, are very distinct.

Family—FUNGIDÆ.

ANABACIA ORBULITES. Edw. and Haime, Brit. Fos. Cor., p. 120, Pl. xx., fig. 3. 1851.

Fungia orbulites. Lamouroux, Expos. Meth., p. 86, Pl. 83, figs 1, 2, 3. 1821.

Examples of this species have been obtained by Mr. Beesley, Mr. Walford, and Mr. James Windowes, from the Great Oolite in the neighbourhood of Ba ıbury and Chipping Norton, as well as at Tadmarton and Hook Norton, but I do not know whether they have been taken from the same bed as the other Great Oolite species from those localities. From what I learn from Mr. Walford, I should think that they occur a little higher up, though I have myself taken this species at Epwell in immediate association with *Calamophyllia radiata* and *Cladophyllia babeana.*

ANABACIA HEMISPHÆRICA. Edw. and Haime, Brit. Fos. Cor. p. 142, Pl. xx., fig. 2. 1857.

Some specimens of this very doubtful species were taken by me some years since from a quarry between Chipping Norton and Chappel-House, only a little way removed from the old coach-road which passed through this part of Oxfordshire from Birmingham to Oxford.

ZOANTHARIA POROSA.

Family—PORITIDÆ.

MICROSOLENA EXCELSA. Edw. and Haime, Brit. Fos. Cor., p. 122, Pl. xxv., fig. 5. 1851.

Siderastræa incrusta. McCoy, Ann. Nat. Hist., S. ii., v. 2, p. 419. 1848.

Several examples were taken by me from the railway cutting at Hook Norton, in the summer of 1878. They differ in no respect from specimens from the Great Oolite of the Hampton Downs near Bath.

MICROSELONA (?)

A small lenticular species, not specifically determinable, was found by myself some years since near Epwell, associated with *Calamophyllia radiata*, *Cladophyllia babeana*, and *Anabacia orbulites*.

ZOANTHARIA TABULATA.

Family—THECOSTIGITIDÆ. E. de From.*

CYATHOPHORA RICHARDI. Mich. Icon. Zooph., p. 104, Pl. 26, fig. 1. 1840-7.

A single example of a coral received from Garsington, Oxfordshire, is obviously referable to the genus *Cyathophora*, as at present restricted by M. de Fromentel. That distinguished zoophytologist has clearly pointed out that the *Cyathophora* of Michelin is quite distinct from the genus as illustrated by the British species placed in it by Edwards and Haime in their "History of British Corals." He has accordingly placed it with the genera *Chonosteigites* and *Thecostigites*, among the tabulated corals, in a family distinguished as above.

M. Michelin describes the genus *Cyathophora* in these words :—"Polyparium lapideum, fixum, conglomerato-globosum vel ramosum, tubulosum ; superficie cellulis immersis ; cellulis sparsis, per diaphragmata transversa divisis, distinctis, obsolete stellatis; lamelli subnullis."†

But Michelin further distinguishes this genus when speaking of the type species, *C. Richardi*, thus :—"Nous a paru devoir former un genre nouveau à cause de ses lamelles laterales peu visibles quoique assez nombreuses et resemblant à des stries."

M. de Fromentel gives the following definition of the genus :—"Polypier massif ; polypierites cylindrique et unis par les côtes qui ne sont pas très-développées ; planchers horizontaux et simples ; cloisons représentées par des stries, plus ou moins saillantes, qui descendent le long de la paroi interne des murailles."‡

Five species are placed by M. de Fromentel in this genus, and they are as follows :—*C. Richardi*, Mich., which is the type species ; *C. alveolata* (*Astræa alveolata*, Goldfus.) ; *C. corallina*, E. de From., all of which occur in the Coral Rag of Natheim. Two

* "Introd. Etud. Polyp. Fos.," p. 277 and 278.
† "Icon. Zooph.," p. 104, Pl. 26, fig. 1.
‡ "Introd. Etud. Polyp. Fos.," p. 278.

other species have been described by M. de Fromentel from the Neocomian formation, under the names of *C. excavata* and *C. antiqua*.

The British species referred to this genus by Edwards and Haime in their "History of British Fossil Corals," have very properly been removed by M. de Fromentel to the genus *Cryptocœnia* of M. d'Orbigny,* and I have followed his example in the present communication, and have done the same with species subsequently described by Prof. Duncan in his "Supplement to the British Fossil Corals." †

In general form the specimen from Garsington bears close resemblance to the figure given by M. Michelin, but is relatively a little higher, and a little more compressed laterally. There is the same disposition to division into vertical lobes as in Michelin's specimen, the crown of which rudely resembles a figure 8.

The base is small, and the corallum probably grew by a small attachment. From this it expands in two opposite sides chiefly producing a somewhat flabelliform figure, with a flat elongated top.

There is no investing wall, and the calices on the ascending part are elongated, and have projecting lower margins, somewhat as in *Alveolites*, and in *Pleurocœnia alveolaris*. On the swollen parts, near the top, they are round, but on the flat top they are squeezed together, and are narrowly ovoid. Over the whole of the corallum they are pretty thickly placed. Their margins are rather prominent and the spaces between them have obscure and rather thick costæ.

The septa are rather numerous, very irregular, and pass like threads down the inside of the calices.

Height of the corallum, 3in. 3 lines.

Longest diameter of the crown, 3in. 3 lines.

Shortest diameter of the crown, 1in. 6 lines.

Diameter of the calices about 1½ to 2 lines.

Although some of the corals of the Inferior Oolite pass upwards into the Great Oolite, the coral fauna of the latter differs remarkably from that of the former, in having a great scarcity of simple species, and in having compound ones which are in general amorphous, dendroid, or globular and gibbous. I have already noted, in a paper on the Corals of the Inferior Oolite of Crickley Hill, Gloucestershire, that there is a decided tendency in both simple

* "Cours. éléments. de Pal.," i., ii., p. 164. 1856.
† "Supp. Brit Fos. Cor.," Pl. iii. 1872.

and compound corals from that locality to assume a flat and expanded form.* All those which I have seen from Oxfordshire are flattened and expanded also, with the exception of *Montlivaltia trochoides*, and *Thecosmilia Wrighti*, but there is a marked dissimilarity between the corals of the Inferior Oolite of Oxfordshire and Gloucestershire, in the almost total absence in the former of simple apices. The only simple corals I have yet seen from the Inferior Oolite of Oxfordshire, are *Montlivaltia lens* and *Montlivaltia trochoides*.

I wish, in conclusion, to take this opportunity of rendering my very hearty thanks to Mr. Beesley, Mr. Walford, and Mr. James Windowes, for the very great readiness with which they have at all times placed at my disposal all the information they possessed respecting the species in their several collections, as well as the free use of the specimens themselves; without which assistance from them this paper could not have appeared.

NOTE.—Since the foregoing was written I have been favoured with a considerable and very interesting series of fossil corals from the Coralline Oolite of Gray, Haute Saône, by M. de Fromentel. Amongst them are some species of *Clausastræa*, and the examination of these has confirmed me in my decision respecting some English species which I had placed in this genus. One of these is the *C. Conybeari* of the present paper.

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2. NOTE ON THE REV. J. F. BLAKE'S PAPER ON THE CHALK OF YORKSHIRE.†

By DR. CHARLES BARROIS.

An interesting contribution to our knowledge of the Yorkshire Chalk has been recently made by the Rev. J. F. Blake. His paper contains a good description of the beds as to their succession and fauna, and very accurate observations on their real thickness. The divisions recognised by Mr. Blake, as stated at p. 262, are six in number. I had formerly pointed out eight divisions in the same area.

A comparison of the zones I had indicated in the Yorkshire Wolds, with the recent divisions of Mr. Blake, as exhibited in the following table, will perhaps be of interest to some :—

* Geol. Mag., July, 1878.
† Proc. Geol. Assoc., Vol. v, p. 232.

Dr. Barrois' Yorkshire Divisions.	*Mr. Blake's.*
Zone of *Belemnitella mucronata* (wanting).	
Bridlington Chalk { many sponges; few sponges }	1. Zone of Marsupites.
Flamborough Head Chalk	2. Zone of Micrasters.
Chalk of Breil Point Grey flinty Chalk of North Sea	3. Barren Zone.
Hessle Chalk Hard Speeton Chalk, with red bands	4. Zone of *Inoceramus Mytiloides.*
Zone of *Belemnites plenus* (unrecognized.)	
Speeton Chalk, with red bands	5. Zone of *Holaster subglobosus.*
Sponge Bed (wanting).	
Zone of *Pecten asper* (wanting).	
Red Chalk of Speeton.	6. Zone of *Belemnites minimus.*

Mr. Blake sums up, on page 262, the results arrived at in his paper as follows:—"It will be seen, on comparison of this table with that of Dr. Barrois' before given, that I suggest the use, in the present state of our knowledge, of larger subdivisions than he admits. It may be true, perhaps, that the smaller ones may be adequately recognized when more work has been done upon this district, and the map of it carefully worked out by stratigraphical observations, but the first step seems to be to mark out the more easily recognized portions before proceeding to the more minute. . . . . Those subdivisions of Dr. Barrois' that I do not recognize are, 1st, the Zone of *Micraster cortestudinarium* (Chalk of Breil Point); 2ndly, the Zone of *Holaster planus* (Chalk, with grey flints of North Sea); 3rdly, that of *Terebratulina gracilis* (Hessle Chalk)."

I do not think it useless, even from a general scientific point of view, to support the divisions I had proposed. These palæontological zones gave evidence of the homogeneity of the English Cretaceous system, and showed that the *Mer-du-Nord* was at the time of the Chalk a great gulf—a limited zoological province, and not an abysmal ocean, as previously supposed

I will examine in succession the six zones of Mr. Blake.

Zones 6 and 5. The description of these zones is very valuable, and full of new information on the changes of the beds inland.

Zone 4 of Inoceramus mytiloides. This division, according to Mr. Blake, comprises my three zones of *Inoceramus labiatus*, *Terebratulina gracilis*, and *Micraster breviporus;* he adds (p. 262),

"These zones may also be recognised in what I have characterized as one, but in that case the *Inoceramus mytiloides* will be found to characterize the middle one rather than the lowest." In fact, we perfectly agree; my three zones (of *Holaster planus*, *T. gracilis*, *I. labiatus*) are united in my paper in the same "assise" (Turonian). Thus the question is, whether the Turonian series of Yorkshire will be subdivided or not? But, *à priori*, it will certainly be divided—the proof being that the recent papers on English Cretaceous geology (Mëyer, Jukes-Browne, Price) have adopted even more minute divisions than I had myself, and I confidently hope that the first zones that will be recognised will be those I have followed all over England.

In reality, Mr. Blake's zone of *I. mytiloides* corresponds only to my zones of *I. labiatus* and of *T. gracilis*. The lower zone (of *I. labiatus*) has afforded me only this single species of *Inoceramus*, the higher zone (with *T. gracilis*) has afforded me numerous *Inocerami*, as stated on p. 195 of my Memoir. I did not venture to name them at the time, with the exception of *Inoc. Brongniarti*, but I have since then again studied my Speeton *Inocerami* on the occasion of a paper now in the press on the Chalk of the Ardennes. They much resemble *I. labiatus*, and I agree in thinking that several of my specimens from that zone may be merely varieties of that species, though there are other specimens far more numerous in that zone, which will be easily found there by any geologist, viz., *Inoceramus cf. cuneiformis* (d'Orbigny, Pal. Franc., p. 512, pl. 407), and *I. undulatus* (Mantell, *fide* Goldfuss. "Petrefacta Germaniæ," pl. 112, fig. 1). The figures of this last-named species are very imperfect, and I named them by comparison with typical specimens from the *Scaphiten Pläner* of Hanover, given to me by the late Mr. Schlönbach.

I will keep, then, the name of Zone of *Inoceramus labiatus* for the lower division of the Turonian, where I found this *Inoceramus* alone; while in the upper division—the zone of *I. gracilis* there are, with *I. Brongiarti*, several other species allied to *I. labiatus*. I may add here, that this zone of *T. gracilis* is *typically* represented in the large quarry at Hessle. The zone of *I. labiatus* was only seen by me at Hessle, in a small abandoned pit below the beds now worked for whiting, road-stone and lime, which are the true *T. gracilis* zone. The uppermost beds, with thick bedded flints, are the only representative of the *In. breviporus* zone in this dis-

trict; it is in this portion of the series that *In. undulatus* is more common.

I do not think Mr. Blake is right when he calls the form I had named *I. labiatus*, by the names *I. mytiloides* and *I. Cuvieri*. I must say a few words about this species. *Inoceramus mytiloides*, according to Mr. Blake, is named from Mantell (Mantell, "Geology of Sussex," 1822, *Mytiloides labiatus* of Brongniart). I gave to this species the name of *I. labiatus* because it was first described under this name by Schlotheim, in 1813, before Mantell's book was published (Schlotheim, in "Leonhard, Mineral Taschenbuch," 1813, vii., p. 93), and there can be no doubt therefore as to priority. This species is very well illustrated—Sowerby's Min. Conch., Pl. 442; and better still, in Goldfuss' "Petrefacta Germaniæ," which is still the chief work on the *Inocerami*. (Pet. Germ., p. 118, tab. 113, fig. 4.)

It is also in Goldfuss' work that I look, with many authors, for the type of *I. Cuvieri* (Sow.) the figure in Goldfuss (Pet. Germ., ta. 111, fig. 1), agrees exactly with Sowerby's description (Min. Con., Pl. 441, fig. 1; and Linn. Trans., 1823); but I cannot consider as the same species that described by Mantell under the same name (Pl. 27, fig. 4, and Pl. 28, figs. 1 and 4). The *Inocer. Cuvieri* of Sowerby and Goldfuss has only been found by me as yet in the zone of *Micraster cortestudinarium*. In the Barren Zone of Mr. Blake, I met with fragments of *Inocerami* which I might have named *I. Cuvieri*, if I had not limited my identifications to specimens sufficiently well preserved to be recognised with some certainty.

Zone 3, or Barren Zone. This zone, lithologically characterized by the maximum of siliceous matter, and which is so well exposed in North Sea Bay, as stated at p. 196 of my Memoir, has afforded, as yet, but few fossils, either to Mr. Blake or to myself. It is, however, worthy of a very careful study; a further knowledge of it is a desideratum, which it is desirable to indicate.

Let us, for a moment, embody in Mr. Blake's *Barren Zone* the beds I had described as the zones of *Holaster planus* and *Micraster cortestudinarium*, in the North of England. My recent studies in the Cretaceous rocks of the Ardennes have shown me that the beds of this district that must be compared with the *Barren Zone* can be subdivided as follows:—

Zone of *Micraster cortestudinarium.*
Zone of *Epiaster brevis*.................. } Assise of *Micraster*
Zone of *Holaster planus* (Chalk-rock) } *breviporus.*

It now remains to be seen whether the zone of *Micraster cortestudinarium*, of whose existence in the North of England, from Norfolk to Yorkshire, I did not find any sufficient evidence is wholly wanting there, as it is in parts of the Ardennes—and whether it is represented, as there, by the zone of *Epiaster brevis?* The sections of these beds in Yorkshire and Norfolk remind me rather of those in the Ardennes district, than of those in the South of England, where a well-developed *Micraster cortestudinarium* zone rests on the Chalk-rock.

Zone 2 of Micrasters. This is an exact equivalent of my *Micraster coranguinum* Zone (Chalk of Flamborough Head). I had found but few fossils in this division, but the interesting discoveries by Mr. Blake and Mr. Mortimer of *Inoceramus involutus*, *In. digitatus*, *Inoc.* nov. sp., *Micraster coranguinum*, *Pleurotomaria cf. perspectiva*, (compare *Pleurtomaria merceyi*, nov. sp.) and numerous sponges, *Ventriculites*, *Brachiolites*, *Scyphia* in this zone, show that it has the same character in Yorkshire as in other parts of England.

Some of the *Inocerami* referred by Mr. Blake to *In. involutus* should be otherwise named. These he describes (p. 251), "like two Nautili with their mouth opposed," but such is not the form of the true *In. involutus* of Sowerby, described by him as "subglobose valves very unequal, one gibbose, even, with a large incurved beak and very hollow sides, the other nearly flat, with deep concentric waves." . . . (Min. Con., Vol. vi., p. 160, Pl. 583). The species referred to by Mr. Blake, with both valves gibbose, is not unknown to me. I found a very good example of it at Compton House (Hampshire), in the zone of *Marsupites*, and I take it to be a new species.

Zone 1 of Marsupites. This is my Bridlington Chalk. The interesting fossils recorded in this division by Mr. Blake as *Nautilus lævigatus*, *Scaphites binodosus*, *Sc. inflatus*, *Sc. compressus*, *Hamites cylindricus*, and *Avicula tenuicostata*, clearly indicate that several minor subdivisions could be traced in this mass of Chalk 300 ft. in thickness, which might easily be compared with those of Prof. Schlüter, who found the same fauna in the North-west of Germany.

3. Reply by the Rev. J. F. Blake, M.A., F.G.S.

The only points in Dr. Barrois' Note calling for a reply, are, first, the correlation of the zone of *Micrasters*, and secondly the nomenclature of the *Inocerami*.

With regard to the first, the *Micrasters* of the Chalk of Yorkshire are scarcely in sufficient number and preservation to enable me to distinguish the occurrence of two such allied species as the *M. coranguinum* and *M. cortestudinarium*, and I therefore refrained from distinguishing them. The Barren Zone attaches itself more to the beds above than to those below, and, therefore, if the range of those two Echinoderms can be proved constant elsewhere, this zone may well be the representative of that of *M. cortestudinarium*.

With regard to the *Inocerami*, some little confusion has undoubtedly arisen amongst students of the Chalk.

1st. *Inoceramus mytiloides* has the following history:—In 1813 Schlottheim catalogued a species by the name of *labiatus*, but gave no figure or description. In 1820 he described a species which is undistinguishable from the one I am referring to, as he gave a reference to Knorr and Walch's figure, and this he called *I. problematicus*, which name, therefore, given by Schlottheim himself, ought to supersede his old catalogue one, as it does with d'Orbigny. In 1822 Mantell described the same as *I. mytiloides*, and not till after that was any currency given to the name of *labiatus* by Brongniart in his "Geology of Paris." Subsequently Goldfuss, Sowerby, Romer, call the species *I. mytiloides*. Under these circumstances, it seems that *I. problematicus* is the right name, and the next best, *I. mytiloides*. This species is a very distinct one, and I still think that Dr. Barrois calls many specimens by this name that have no relation to it. I may be equally wrong in calling them after the great Upper Chalk form *I. Cuvieri*, to which they bear most resemblance, and they are perhaps the *I. undulatus* of Mantell.

2nd. *I. Brongiarti*. Mantell first used this name for a species which had already been called *Lamarckii* by Parkinson, and gave to the species, which should have been regarded as new, the latter name. Sowerby corrected this error, and applied the name *Brongniarti* to a really undescribed species. There is thus a great confusion between the names, though none between the species. The

species, however, which Mantell had called *I. Cuvieri*, may really also be his *Brongniarti*, while his *I. latus* is the true *Cuvieri*.

3rd. I quite agree that the species I have called *I. involutus* is very probably a new species which, when described, might well be called *I. Barroisi*.

VISIT TO THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS.

APRIL 5TH, 1879.

Director:—PROF. FLOWER, F.R.S., Conservator of the Museum.

(Report by Prof. Flower).

Prof. Flower particularly directed the attention of the Members to the skeletons of Cetacea, of which the Museum contains a fine series. After some general remarks upon the characters of the Order, he pointed out that all the known species, both living and extinct, could be arranged under one or other of two primary groups—the *Mystacoceti*, or Whalebone Whales, and the *Odontoceti*, or Toothed Whales; and that at present no transitional form between these two have been met with. The earliest known, the Zeuglodonts of the late Eocene formation, were Odontocetes. To this group belonged the great Sperm Whale, or Cachalot, of which a complete skeleton from Tasmania hangs in the Museum. In the upper jaw the teeth are quite rudimentary, but the long and narrow lower jaw is armed with a double row of nearly fifty in number. Allied to this species are the various Ziphioids, in which the teeth are still further reduced, those of the upper jaw being usually absent, and the lower, not more than two or four in number, sometimes developed as projecting tusks, sometimes quite concealed beneath the gum, so that in the latter case the animal is practically toothless. Specimens were shown of the dense bony rostra, and the teeth of various Ziphioids from the Red Crag of Suffolk, and the relations and structure of their fragmentary remains illustrated by comparison with more perfect examples of existing species. The other Odontocetes, the common porpoises and dolphins, the singular fresh-water dolphin, or *Platanista* of the Ganges, the Beluga, or White Whale, and the Narwhale, with its one immensely developed, spirally twisted tusk, were next passed in re-

view. The Whalebone Whales were then considered, and the nature and use of the horny laminæ developed from the palate, the baleen, or "whalebone" of commerce, was demonstrated, and the characters of the Greenland Right Whale, and of the Fin-back Whales, shown by means of their respective skeletons, and by diagrams representing their external appearance. Fossil remains were shown of Whalebone Whales from the Crag, chiefly limited to the densest portion of their osseous structure, the tympanic, or ear bones, which have been preserved when nearly every other part of the skeleton has been ground to dust by the action of waves and rocks, and are the sole evidence of the existence of these animals in great numbers and variety at that early period. At Antwerp, however, where the deposits have been undisturbed, cetacean remains are found in immense abundance and excellent preservation, and may be studied in the superb collection now arranged in the Brussels Museum.

EXCURSION TO WEYMOUTH AND PORTLAND.

EASTER MONDAY, APRIL 14TH, 1879, and following day.

Directors:—Rev. J. F. BLAKE, M.A., F.G.S., and W. H. HUDLESTON, Esq., M.A., F.G.S.

FIRST DAY.—Members left Waterloo at 8.5 a.m., and alighted at Upway Station, between Dorchester and Weymouth. Here the party were met by the Directors, and proceeded to inspect the quarries on Ridgeway Hill, principally in the Purbecks, 190ft. thick, beneath which is a considerable thickness of Portland limestone with large fossils, and many flints. The Railway, as it emerges from the tunnel underneath Bincombe Down, affords in the cutting a section which has thrown much light upon the Ridgeway fault. From the neighbourhood of Upway the party took the most convenient route to Osmington, and reached the coast at Osmington Mill. The disturbance, which further west has produced the saddle of Forest Marble, may here be noted as a fault. Near the Cascade, the Calc Grits at the base of the Corallian Series are well exhibited. The tide being suitable, the party proceeded westwards along the scar at the foot of the cliffs, and examined the very fossiliferous exposure of the Corallian *Trigonia*-beds capped by an alternating series of clays and red grits, and sur-

mounted by Kimmeridge Clay. Further westward they regained the summit of the cliff, walked along the footpath to Jordan Hill, and thence proceeded to Weymouth.

SECOND DAY.—The party met on the Jetty, beneath the Nothe Fort. The Harbour lies on Oxford Clay, and immediately to the South begins the Corallian Series. An examination was made of the upper succession of Nothe Grits, Nothe Clays, Bencliff Grits, Oolites and *Trigonia*-beds; to which succeed the Sandsfoot Grits and Clays, and these the Kimmeridge Passage-beds. A Sea-wall has here been built on the Kimmeridge Clay, to counteract the effects of the change of currents brought about by the breakwater. The party then proceeded towards Chesilton by the shore, and noted the increasing size of the pebbles of the Chesil Beach towards Portland. Proceeding eastwards, beneath the Vern, the section upwards from the Portland Sand was examined. The latter is here somewhat argillaceous, and contains beds of oysters. The Portland rock, with its "Roach," was seen in most of the quarries on the summit, capped by the Purbecks with their Dirt-beds. Returned by train to Weymouth.

The following explanation of the geology of this district was given with the programme of the Excursion:—

The importance attaching to such a district, so full of geological and stratigraphical interest, has long been perceived. There is probably no other place in England where so many formations are exposed within an equal space as between the Forest Marble axis and the edge of the Dorsetshire Downs, whilst the Oolitic members of these formations are repeated on the south side of the anticlinal.

The *Forest Marble* and *Cornbrash*, constituting the upper division of the Lower Oolites, consist, within the district, of grey marls and marlstones, blue clays, and beds of stone, composed of comminuted shells, covered by a loose rubbly limestone alternating with thin beds of clay. The *Oxford Clay* is estimated to be 300ft. thick. In the backwater of Weymouth it has yielded many characteristic ammonites, and large septaria which used to be cut into slabs. The *Corallian* series, formerly known as the Coralline or Oxford Oolite and Calcareous Grit, and more recently as Coral Rag, has a thickness of about 230ft. on the south side of the anticlinal, and of about 180ft. on the north side. It consists of a central core of impure limestones, sometimes oolitic, and in places

extremely fossiliferous, bounded above and below by calcareous grits and clays in several alternations. Corals are rare, but most numerous towards the top of the upper grits. The *Kimmeridge Clay* is probably nearly 1,000ft. thick ; it is more bituminous than the Oxford Clay. The clay bottom of the anchorage at Portland is in this formation. The *Portland Sand* is 80ft. thick, and though usually glauconitic, it is scarcely, if at all, so in this area. The *Portland Stone* has been estimated at 75ft. on the Island, the lower portions are very siliceous. The *Purbeck* Series, being for the most part of brackish water origin, is very variable; only a few feet of the lower division now remains on the Island of Portland. The *Hastings Sands*, though not shown on the Section, are stated to occur in the Ridgeway Cutting, and are marked on the Survey Map to the east of Osmington. The "*Upper Greensand*" is stated to be about 100ft. thick, and consists, towards the base, of dark argillaceous greensand, succeeded by variegated sands, alternating with irregular calcareous concretions and thick beds of chert, and capped by a chalky, and in places fossiliferous glauconite, known as the *Chloritic Marl*, upon which rests the *Chalk*, which itself is capped by outliers of the *Lower Tertiaries* of the Hampshire Basin. The contents and mode of occurrence of some of the *Quaternary Beds* have afforded material for most important investigations relative to the age of upheaval and sculpture of the anticlinal.

EXCURSION TO CRAYFORD AND ERITH.

SATURDAY, APRIL 26TH, 1879.

Director.—Professor MORRIS, M.A., F.G.S.

The party took the train at Cannon Street for Crayford station, whence, under the guidance of Professor Morris, they proceeded to the extensive excavation known as Stoneham's Pit. At this place fine sections of the Lower Brick Earths of the Thames Valley are exposed. The beds here exhibit three distinct conditions of deposition, and are very fossiliferous. In an adjoining pit may be seen an interesting section of the Old River Channel showing the excavation of the Chalk and Thanet Sands. The surface of the Chalk is here eroded by chemical action into pipes and basin shaped cavities, into which the Thanet Sands have broken through. Following the Cray valley and passing over the Brick-

earth, which here constitutes an unbroken mass, the village of Erith was reached, and the well known excavation (White's Pit) near the village was visited. The phenomena observed at Crayford and Erith were similar to those described in the report of a previous Excursion of the Association to this locality (see Proc. Geol. Assoc., Vol. III., p. 83), though, as the pits are being continuously worked, the sections are somewhat different at each visit. The party returned to London from Erith station.

ORDINARY MEETING.

MAY 2ND, 1879.

Prof. J. MORRIS, M.A., F.G.S., Vice-President, in the Chair.

The Donations received since the previous Meeting were announced, and the donors received the thanks of the meeting.

The following were elected Members of the Association :—

C. C. Gibbs, Esq., M.D., and William A. Tooke, Esq., J.P.

The following Paper was read :—

ON THE DINOSAURIA.

BY. Prof. H. G. SEELEY, F.R.S., F.G.S., &c.

The Dinosauria were first identified as a distinct division of the Reptilia, by Von Meyer, who compared them in appearance to the larger and heavier land mammals, and named the order Pachypoda. But Von Meyer's opportunities of elaborating the group were not many, and the more important materials found in the South East of England have long furnished us with our best ideas of its structure. At first Mantell, whose great merits as an original interpreter of these animals are in no danger of being forgotten, classed the Iguanodon and similar animals under the general name of Saurians, on account of their resemblance to lizards, and at a time when naturalists were far from agreed as to whether the Order Sauria should not include both lizards and crocodiles. Later, Professor Owen founded on these English specimens the Order Dinosauria, and gave it a scientific definition by which Dinosaurs were clearly separated from most other animals. The border line, however, was sometimes difficult to limit, and some

animals, like *Protorosaurus*, which are probably Dinosaurs, continued to be classed with the lizards, while others, like the Belodons and Thecodontosaurs, also probably Dinosaurs, were classed with the Crocodilia. The structure of the best known Dinosaurs was, however, so remarkable that many important parts of the skeleton were misunderstood and wrongly identified. And it was not until Prof. Huxley showed that the supposed coracoid was an ilium, and the supposed clavicle an ischium, that the true structure of the limb arches came to be understood.

These conclusions were largely the result of Prof. Phillip's work on *Cetiosaurus*, at Oxford; and the Oxford collection, I believe, contained a cast of Deslongchamps, astragalus and tibia of *Pœcilopleuron*, which demonstrated a hitherto unsuspected resemblance to birds in this part of the skeleton. That resemblance, coupled with the bird-like form of the ilium, and many other bird-like characters, especially as shown in *Compsognathus* from the Solenhofen Slate, led Prof. Huxley to enunciate the ornithic affinities of the group, and to regard these animals as intermediate between living reptiles and birds. Prof. Cope, about the same time, made almost identical discoveries, and during the last ten years our knowledge of the Dinosauria has been augmented by the description of many new types, though the generalizations of earlier years have not been revised. With the possible exception of the Permian *Protorosaurus*, Dinosaurs are only at present known from Secondary strata. The chief countries which have yielded them are England, Belgium, France, Germany, Austria, Russia, India, and the United States.

The Trias appears to have been especially rich in Dinosaurs, since they are met with in all parts of the world. In our own country they are well represented by *Palæosaurus* and *Thecodontosaurus*. In the Lias succeed *Scelidosaurus*, and another genus at present undescribed. *Megalosaurus* appears to range from the Lias to the Upper Greensand, though it is chiefly characteristic of the Stonesfield Slate and Wealden Beds. *Cetiosaurus*, if such a genus can be retained, abounds in the Forest Marble and Kimmeridge Clay and Wealden Beds. *Cryptosaurus* is from the Oxford Clay. *Priodontognathus* is probably from beds of Corallian age. The Dinosaurs of the Kimmeridge Clay include *Omosaurus* and *Gigantosaurus*. From the Wealden Beds are *Iguanodon*, which ranges down to the Kimmeridge Clay and up to

the Upper Greensand, *Pelorosaurus*, *Hylæosaurus*, *Hypsilophodon*, *Polacanthus*, and *Ornithopsis*, besides other genera still undescribed. The Upper Greensand also abounds in Dinosaurs, among which are various species of *Anoplosaurus*, *Syngonosaurus*, *Encercosaurus*, and *Acanthopolis*. The last genus also occurs at the base of the Chalk. The Dinosaurs of the Continent are mostly of the same ages as those of this country, except that at Maestricht there are some newer types allied to *Iguanodon*, and a Dinosaur, probably of another genus, figured by Dr. Fritsch, from the Chalk of Bohemia. The Gosau formation of Austria has yielded to Prof. Suess a large reptile fauna in which are the remains of many Dinosaurs, including *Struthiosaurus* and *Danubiosaurus*. Quite recently, in Belgium, beds, believed to be of Wealden age, have yielded Dinosaurs closely related to, if not identical with, *Iguanodon*, in more perfect condition than any that were previously known, and probably in greater abundance; and it is remarkable that on or about these horizons in North America the Dinosaurs have chiefly occurred, in the Upper Greensand of New Jersey and the Upper Oolite or Wealden series of Colorado. The Lower Oolites are nowhere very rich in Dinosaurs, and if Mr. Hulke's identification of *Pœcilopleuron* with *Megalosaurus* be established, we know of no other genus from the Lower Oolites. No foreign Dinosaurs are known from the Lias, but from the Trias we have *Zanclodon*, admirably preserved at Stuttgart and Tübingen; *Teratosaurus*, *Plateosaurus*, *Belodon*, and others.

It is remarkable that the oldest Dinosaurs are eminently crocodilian, and have the ilium chiefly directed backwards, with only a slight forward process, while in later genera the anterior process elongates, and the form of the bones becomes more bird-like; while in some of the American forms, figured by Prof. Marsh, such as *Morosaurus*, the mass of the ilium has an anterior or mammalian direction. The whole skeleton similarly undergoes change. The skull, which at first is elongated in *Belodon*, and somewhat resembles a crocodilian skull, compressed from side to side so as to be arched in the middle line, becomes contracted in length; so that in the Wealden Dinosaur *Iguanodon*, the brain case is completely closed; and in *Hypsilophodon* the orbits of the eyes abut against the frontal bones, as in mammals and some birds. The brain, however, if its form may be judged from the figure given by Mr. Hulke, is essentially reptilian. Though remarkable for great compression from side to

side, remarkable shortness and unusual height, it appears to prove the optic lobes to have been well developed between the cerebrum and cerebellum. The Dinosaurian skull presents obvious points of affinity with the Teleosaurs, yet the palate is altogether different; the quadrate bone, as in *Hatteria*, sends a long process inward and forward to unite with a similar process given off from the hinder margin of the short and somewhat rhomboidal pterygoid bone, while the palatine bones appear to have been narrow and much more slender. These elements are seen in *Scelidosaurus* and some specimens of *Hypsilophodon*. The teeth of Dinosaurs are extremely variable It may be doubtful whether all Dinosaurs show the distinction into incisor and molar types, but no animals at present recognised as Dinosaurs have canine teeth, though it is possible that some of the South African, so-called Theriodonts, may prove to be Dinosaurs thus characterized. The distinction between molar and incisor teeth, moreover, is only marked in the herbivorous Dinosaurs; but the character is equally well defined in several lizards, such as the *Cnemidophorus lacertinoides*, from Mexico, in which the molar teeth are defined by crowns with cusps similar to those of mammals. The atlas and axis form a characteristic portion of the Dinosaurian skeleton. In *Zanclodon* the dentata and other elements are separate, as in crocodiles, and the bones are entirely crocodilian in shape; but in the later forms from the Wealden the dentata is completely blended with the axis, as in birds, and in *Acanthopolis* from the Upper Greensand the same condition is met with, so that the crocodilian characters become lost. The cervical vertebræ in many Dinosaurs have the centrum convex in front and concave behind, as among ruminant mammals. Formerly this condition was thought to characterize a peculiar genus, and vertebræ having this feature were all referred to *Streptospondylus;* but the condition is absent from some at least of the Triassic Dinosaurs, and from all the Cretaceous Dinosaurs, and will probably be found to characterize family groups. It cannot be regarded as a mark of affinity among Dinosaurs, but, as in ruminants, is probably correlated with the mode in which the muscles of the neck distributed the strains on the osseous tissue and thus determined the directions in which the bones grew. In *Anoplosaurus* from the Upper Greensand the centrums are all nearly as flat as in ordinary mammals; while in some animals from the Cape of Good Hope, considered by Prof. Owen to be Dinosaurs,

the centrums are almost as deeply cupped as in *Ichthyosaurus*. In the neck the ribs are very short, with a double articulation. They are somewhat crocodilian in *Zanclodon*, only smaller and more slender; and the cervical vertebræ are considerably elongated. The dorsal region of a Dinosaur, however, is more peculiar; the viscera have obviously pressed upon the vertebræ with considerable force, as though the lungs were unusually developed. For while the transverse processes in Crocodiles only rise a little above the level of the centrum in the first six or seven dorsal vertebræ, the transverse processes of most Dinosaurs are given off from a platform which is elevated considerably above the centrum, and a strong buttress usually descends on the side of the neural arch from this transverse platform. What is the anterior head of the rib in the Crocodile remains attached to the side of the neural arch, and the posterior head or tubercle is attached to the transverse process. The possibility of this condition as a modification of the Crocodilian plan is barely foreshadowed in those vertebræ between the neck and back, which are called pectoral, but birds similarly have a horizontal platform, and a like mode of articulation for the ribs, while the land tortoises prove that the pressure of the lungs is competent to compress the dorsal vertebræ to a much greater amount than is seen in the Dinosauria. The sacrum is not uniform. In *Zanclodon* it consists of two vertebræ, as in crocodiles; in other genera the number increases until there may be six, as in *Anoplosaurus*, and possibly more; but as in the bird these extra vertebræ are probably taken in from the back and the tail, owing to the functional development of the iliac bones; and it may usually be seen that the sacral ribs are not uniform in size, and frequently the middle [illegible] are largest. The spinal cord swells out immensely in the [illegible] region, so that in *Anoplosaurus* the neural canal is there wider than the entire dorsal centrum. This condition [illegible] the great functional activity of the hind limbs [illegible] fore limb, a conclusion supported by the [illegible] for the sacral nerves. Yet although some [illegible] thus to have indicated a mode of progres[illegible] jerboa or bird, there is no reason for [illegible] was not a quadruped, or that many [illegible] walk on four feet. The tail varied in [illegible] among mammals. In the allies of

Iguanodon and *Megalosaurus* it appears to have been greatly elongated. *Macrurosaurus* of the Cambridge Greensand and the American genus *Lælaps*, show that this condition remained to a late period; but other genera, like *Anoplosaurus*, had the tail singularly short, and including few vertebræ. The back and sacrum appear always to have been convexly arched, while the tail had its upper margin concave in length. This is proved by the lower margin of the centrum being the shorter in the back, while the neural margin is always the shorter in the tail. Taken as a whole, the vertebral column may be best compared with that of a reptile, but it differs from a reptile in characters which indicate that the lungs were considerably developed, and that the bipedal position was possible. It may be questionable how far this modification of the vertebral column, by means of the lungs, was connected with the development of dermal armour, which, by exercising pressure and resistance to be overcome, may have promoted the growth of the lungs on the one hand, and compelled them to press against the vertebræ on the other. One influence of dermal armour in the Cretaceous genera is seen in flattening and expanding the surface of the ribs which carried the plates so as to give their cross section the shape of a T. The scapular arch most nearly resembles that of the Chæmeleon and the New Zealand lizard *Hatteria*, and those bones differ from the corresponding elements in Dinosaurs in little except size. Yet it is possible that the bones may have been modified from a Crocodilian type. The scapula is not altogether dissimilar, and the coracoid may have undergone functional modification of form. Certainly there is no near approach to the coracoid of a bird, though the scapula is not dissimilar. The pelvis, as already remarked, shows a progressive modification of the ilium, which indicates a curious evolution of muscular structure. The ischium appears to have been slender, and to have been directed backward, as in some struthious birds, while the pubis often, if not always, presents a shape unparalleld in these animals. When Prof. Cope first described the Dinosaurian pelvis, he stated that the pubis was directed forward, as in crocodiles. Later, Prof. Huxley showed that part of it at least was directed backward parallel to the ischium. Subsequently Mr. Hulke was able to prove that the pubis has an anterior, as well as a posterior limb; and more recently Prof. Marsh has figured specimens from Colorado, in

which both the forward and backward portions are seen. The forward portion is probably homologous with the slight pre-pubic process of the *Apteryx*, but it is as long as the backward portion. The pelvis as a whole but for this process, which is lacertilian or chelonian, is very bird-like, but it becomes a matter for consideration whether, in face of so many probabilities of crocodilian descent, the pelvis can be taken as proving a genetic connection with birds. It has been seen that the sacrum augments, and the ilium changes the direction of its axis, and that the animal alters from a quadruped to a biped. Under these circumstances it seems easier to believe that the biped animal has the form of bones characteristic of such bipeds as birds and mammals, than that the form of the bones should be held in some obscure way to demonstrate an affinity between Dinosaurs and Birds, which the remainder of the skeleton does not sufficiently substantiate. Probably only the intermediate Iguanodont genera have the pelvis ornithic even in shape, while the older types, like *Zanclodon*, are reptilian, and the Colorado forms, like *Morosaurus*, show not merely a tendency towards a mammalian form of ilium, but a development of prepubic processes which, though paralleled in *Ornithosaurus* and *Monotremes* by separate ossifications, are curiously like marsupial bones in their slender form.

The bones of the fore limb appear to have been shorter than those of the hind limb, much as in the Teleosaurian crocodiles, though in all Dinosaurs the limbs were relatively larger, stronger, and longer than in that group. The humerus, in its expanded proximal end, is distinctive, and perhaps not nearer to any one order of reptiles or birds than another, but, on the whole, it is reptilian. The ulna and radius are also remarkable, especially in the circumstance that the proximal end of the radius is placed in front of the ulna, which receives it in a deep groove in some genera, and the ulna also develops a large olecronon process which has a mammalian form. In the lizard the ulna is entirely on the outer side of the radius, and there is no crossing of the bones, such as may be seen in the specimens in the British Museum. The carpus is at present imperfectly known. In some Dinosaurs it may perhaps consist of one row of bones only, in others it may consist of two rows. The bone which Mantell supposed to be a nasal horn, and Owen at first considered to be a claw phalange, and subsequently interpreted as a genital spur attached to the inner side of the

carpus, is almost certainly a claw phalange of the innermost digit. The number of metacarpals is often five, though it is possible that the number may be fewer in some genera. The digits always terminate in claws which are sometimes compressed from side to side, and sometimes flattened from above downwards, as among Chelonians. The hind limb of late years has been generally regarded as more avian, but the humerus is perhaps better to be compared to that of a mammal. It is distinguished from all other animals by having a proximal trochanter at the outer anterior margin. The head of the bone is rarely or never separated from the shaft by a neck. The trochanter on the inner side of the shaft, which is sometimes called the third, and regarded as peculiarly Dinosaurian, is really homologous with the lesser trochanter of the human femur, which is relatively higher up. From it a strong muscular ridge sometimes ascends in a curve to the superior and outer margin of the proximal articulation, and this ridge there are good reasons for regarding as corresponding to the posterior intertrochanteric ridge of human anatomy. The characters of the trochanters separate the bone alike from birds and reptiles. The tibia and fibula are hardly more bird-like; the expanded proximal end of the tibia might as well be compared to the mammalian modification as to that of a bird, but the tibia is altogether unlike that of a bird in being prolonged distally to meet the os calcis. The tarsus would appear to be very variable; in *Megalosaurus, Pœcilopleuron* and most English Dinosaurs the astragalus presents the remarkable pulley form which is well known to characterize many birds, and the tibia is modified to fit it. This is certainly a true resemblance to birds, but the character is perhaps less important from the astragalus and calcaneum being separated, as was pointed out in some American genera by Prof. Cope. The discoveries of Prof. Marsh indicate to us Dinosaurs, in which no such condition is met with, and in which the tarsus is formed by two rows of bones giving no indications of bird-like characters; and since the condition of the tarsus is constant among birds, it may be that the morphological importance of the characters of this region in Dinosaurs has been over estimated.

This review of Dinosaurian structure teaches us that neither in the head nor vertebral column, nor fore limb, or pectoral arch are the characteristics of the type avian; while the avian features of the pelvis and hind limb, such as they are, are not developed in all

Dinosaurs. There is, however, a remarkable Dinosaurian group which perhaps may approximate somewhat nearer to birds; it is represented in this country by remains from the Wealden, for which I ventured ten years ago to form the genus *Ornithopsis*. At that time the two vertebræ in the British Museum had received but little attention, and one of them had been figured more than once as the tympanic bone of *Iguanodon*. It differed from all other British Dinosaurs in the thinness and lightness of its bones, which were excavated by immense air cells. Prof. Owen has since suggested more than one additional generic name for this genus, but *Ornithopsis* perhaps best expresses its superficial bird likeness. As no such structure had ever been detected in a Dinosaur, while it was characteristic both of Pterodactyles and Birds, I ventured to predict that this genus would become the type of a new Order of animals, which would bridge over something of the interval between Ornithosaurs and Dinosaurs. The wonderful discoveries in Colorado by Prof. Cope of *Camarosaurus* and allied genera; and by Prof. Marsh of *Morosaurus* and similar forms, shows that the type of *Ornithopsis* attained not only an immense size, but a varied generic development in the New World. In this country the Rev. Mr. Fox (of Brixton, in the Isle of Wight) has fortunately acquired a large series of vertebral remains of this genus, and the type is further known in the Kimmeridge Clay, and is probably represented by the so-called *Cetiosaurus* from the Forest Marble in the Oxford Museum. Prof. Cope had in 1867 proposed to divide the Dinosauria into two Sub-Orders, afterwards increased to three. First the Symphopoda, represented by *Compsognathus* of the lithographic-slate, in which the tibia and fibula are completely blended with the proximal row of the tarsus; secondly, the Goniopoda, in which the proximal tarsal bones were principally represented by a large astragalus which embraces the tibia, and is immovable; and thirdly, the Orthopoda, typified by *Seclidosaurus* in which the tarsal bones are quite separate from the tibia and fibula. To these must now be added a fourth Sub-Order to comprise *Ornithopsis*, *Camarosaurus*, *Morosaurus* and their allies, for which Prof. Marsh suggests the name Sauropoda. The Dinosaurs are not altogether without resemblances in some respects to the other extinct group of animals with which their remains are associated, but in none perhaps are the resemblances so singular and suggestive as among the Ichthyosauria. It would by no means

unfairly represent this affinity to say that the Ichthyosaurs show what the parent types of the Dinosaurs might have become if they had been exclusively developed in the sea instead of upon land. Nevertheless, the difference is now far too great between these orders to permit of their being united together. Both the Ichthyosaurian skull and the form of its brain-case offer certain Dinosaurian resemblances which may be better understood if we speak of them as Crocodilian resemblances. The vertebral column of the South African animals which Prof. Owen classes as Dinosaurs, if correctly determined, closely approximates in form of the inter-vertebral articulation to *Ichthyosaurus*, while the double articulation for the head of the Ichthyosaurian rib is only intelligible as a Crocodilian, or Dinosaurian character, which has acquired its Ichthyosaurian modification in consequence of the aquatic life of the animal relieving the vertebræ from the pressure of the lungs upon them, so that the transverse processes of the neural arch have become lost, and the tubercles, to which their articular facets are reduced, have descended upon the sides of the centrum. The pectoral arch of the Dinosaur may sometimes perhaps contain an interclavicle, as may be seen in the bone which Prof. Phillips regarded as the sterum. If so, it is of quite a different form to the interclavicle of *Ichthyosaurus*, but the coracoid and scapula are closely paralleled in *Ichthyosaurus*, so as to suggest that the difference is no more than might result from functional development; but here the details of correspondence cease—the extraordinary aquatic limbs of *Ichthyosaurus*, like its simple pelvis, admit of no comparison with the terrestrial Dinosaurs. The resemblances to Ornithosaurs, especially in the skull, would admit of some elaboration.

On the whole the Dinosaurs offer a more perfect history of successive modifications of structure than any other extinct group. At present there is no certain evidence as to what the type was from which they were originally modified, but the many resemblances which they offer to the Teleosauria and Triassic crocodiles, as well as to existing crocodiles, permit no doubt that at least some forms of Dinosaurs were more nearly related to crocodiles than to any other reptiles which now survive. The resemblances, however, are not sufficiently close to preclude a suspicion that extinct forms, which connected Crocodiles with the Amphisbænians, may perhaps have more nearly bridged over the gap between the two groups. The resemblances, which have been

noted between the forms of some Dinosaurian bones and corresponding parts in the skeletons of birds, are probably connected with the muscular development necessitated by a semi-erect or bird-like mode of progression, and are not much more important as a mark of affinity to other animals than are the still slighter resemblances of some bones to those of mammals; but these modifications serve to show an evolution within the Dinosaurian group, which is the more valuable, as it indicates the acquisition of the bone forms which are characteristic of higher animals. There can be no doubt that side by side with the modification of the skeleton the vital organs also put on certain changes. This is especially shown in the remarkable modification of the lung, which is distinct from that of birds and Pterodactyles, and yet in *Ornithopsis* shows that large air cells were prolonged from the lungs so as to penetrate into and absorb and excavate the substance of the vertebræ. This, however, may not necessarily imply bird-like organization, but it is a higher organization, and more bird like than that shown by living reptiles.

EXCURSION TO NEWBURY.

MONDAY, MAY 5TH, 1879.

Directors:—The President, Prof. T. Rupert Jones, F.R.S. F.G.S.; and Walter Money, Esq., F.S.A., Hon. Sec. Newbury, District Field Club.

(*Report by* Prof. RUPERT JONES and the HON. LIBRARIAN.)

Having arrived at Newbury, the party from London were met by the Directors, and proceeded to the Town Hall, where Prof. Rupert Jones gave a general sketch of what the proceedings of the day would be.

The carrying out of this programme led the Members, in the first place, to the Parish Church (St. Nicholas), to see the monumental slab of the celebrated John Winchcombe, or Jack of Newbury. This tablet, built into the wall under the tower, appears to have been cut from a kind of Purbeck Marble, now seldom used, and contains many Unios (?) and other Bivalves, with comparatively few Paludinas.

The Rector, who here joined the party, then kindly pointed out some other objects in the church, chiefly of antiquarian interest, including the registers and some portraits in the vestry.

Passing thence to the Museum, the visitors examined the Mammalian remains and Shells from the Peaty deposits of the Kennet Valley, and some Roman antiquities from the neighbourhood, which were laid out by the kind care of the Curator, Dr. Palmer, and the Librarian.

After a short walk, the Clay Hill pits were reached. The section here exposed showed all the beds from the Chalk up to the London Clay, inclusive. Professor Jones pointed out that the surface of the Chalk is here quite level, having formed the floor of the sea bed on which the subsequent deposits were laid down. The perforations that riddled the upper foot or so of the Chalk had, he said, been attributed by Mr. Hudlestone to the hollows left by the roots of seaweeds flourishing on the old sea-bottom. Resting on the Chalk were the green-coated flints which here form the base of the Reading Beds. These last consist of sandy clays full of green glauconitic grains, succeeded by the Oyster-bed, the blue shales with lignite and plant remains, a bed of fine white sand, and (in the upper pit) the mottled clays of the Reading Series, and the lower beds of the London Clay, with its Basement-bed here represented by a band of pebbles.

A pond, into which ran a small stream forming a miniature delta, gave Professor Jones an opportunity of practically demonstrating the way in which the above-named succession of beds had been deposited; whilst their extension, and their relation to the geological features of the surrounding country, were explained and illustrated by large diagrams brought for the purpose.

Ascending to the top of the hill, a magnificent view of Newbury and the country was obtained, and the party listened with great interest to the account of the Second Battle of Newbury, given by Mr. Walter Money, F.S.A. Another short walk, and Shaw House was reached, where the party were received by the Hon. and Rev. J. H. Nelson, and, with the kind permission of Mrs. Eyre, the present occupier of this handsome Elizabethan Mansion, were enabled to see the relics of the Second Battle, and of the siege of Shaw House, preserved in the hall. Mr. Money spoke of these interesting memorials, and read from a contemporary newspaper an account of this Hall when occupied by the wounded soldiers of the Royalist army. Passing round the grounds of Shaw House, and through Shaw Church, an advance was made on Donington Castle. The Castle stands on a spur of the Chalk capped by Lower

Tertiaries. Some interesting examples of swallow-holes were pointed out by Professor Jones.

The rain-water falling on the hills is absorbed by the sands on the top, but, meeting with clay-beds below, it is thrown out again on the hill side, down which it runs until it reaches the Chalk, when it is re-absorbed, and gradually forms, by its solvent action, those pits known as swallow-holes, producing below the surface the well-known phenomena of Pot-holes.

A well had been sunk a short time back at a house on the hill-side, several feet below the level on which the Castle stands, and a member of the party showed some oyster shells from the shell-band of the Reading Series, which had been brought up thence from a depth of 80ft.

Some discussion took place, whether, coming from such a depth, they might not have fallen from the side of the shaft, as a chalk-pit visible from the spot was not more than that distance in vertical depth below the Castle itself; and, indeed, it was learned that the shaft had been dug with difficulty on account of in-fallings.

Most of the party mounted the winding-stairs of the Castle, and studied the physical features of the landscape, with the Chalk hills of Hampshire bounding the wide heaths of Bagshot Sands on the south. Mr. W. Money here pointed out the line of the flank march of Cromwell, and the site of the manœuvres connected with the battles of Newbury.

Traversing, by permission of Mr. Best, the grounds belonging to Donington Grove, through which the Lamborne flows, and, passing through the village of Speen, the next halt was made at "Our Lady's Well." This ancient and once holy well is fed by springs from the gravel on which the village stands. To the presence of these springs the coombe-like valley below is to be traced. After tasting the water, and testing the echo between the well and the neighbouring church, the march was resumed towards Speen Moors. Speen Church, with its very old dedication stone of cross and circle, was passed in the opening of the coombe; and the evidences of Roman and British occupation of the neighbourhood were discussed.

A few yards lower down Professor Jones pointed out, *en route*, a section showing the subsoil of chalk on which reposed the old gravels of the river. Still lower down in the broad, level valley of

the Kennet some very interesting sections in the peaty deposits that fill it were visited. Some spots were pointed out where the peat had, comparatively a few years back, been excavated, and entirely filled up with fresh accumulations of vegetable growth. In one notable instance, the peat had, only 20 years ago, been dug out to a depth of 10 feet, but the pit is now filled in to within three feet from the top, *Equisetum* being an active agent among the infilling plants. Professor Jones here gave an interesting account of the formation of these low-level peats, and read a list of the water and marsh plants that compose them.

Resting on the top of the peat was a calcareous, loamy bed, full of shells of land and fresh-water Mollusca, and locally called "Malm." This "Malm," or Marl, like the brick-earths of the lower Thames Valley, is a flood-water deposit, the shells having been left behind when the swollen stream returned again to its usual channel. Layers of deserted *Limneæ*, coating the bottom of nearly dry ditches in the water-meadows close to the Kennet, served as existing examples of such an accumulation of shells.

The best example, however, of this "Malm" was seen in a shaft in the West Fields, close to the town, sunk for the occasion by the borough-surveyor, Mr. Sargent. Many of the shells found in this section were coated with concretionary carbonate of lime. A like incrustation coats the Caddis-worm cases, so that they resemble those of the Indusial Limestone of Southern France.

Mr B. B. Woodward informs us that, with regard to the incrusted cylinders and Caddis-cases, the first that was opened was probably the mould of a twig. In the next example were a number of smaller incrusted twigs, which had, from their size, been apparently used in the construction of a case of basket-like interlacement, in true Caddis fashion.

Another seemed to have been built of the thin leaves of water plants, and may have belonged to the swimming Caddis; whilst a fourth exhibited in its wall a small shell *(Planorbis)*, evidently from its position once part of a Caddis case.

Returning to the Town Hall, the party were received at dinner by the Mayor, the Rector, some members of the Corporation, and of the Field Club, and thus concluded a most enjoyable occasion, to which the pleasant fellowship of the Newbury people, and the exceptionally fine warm weather, not a little contributed.

EXCURSION TO ORPINGTON AND KNOCKHOLT.

SATURDAY, MAY 10TH, 1879.

(First of the Weald Series.)

Director—J. LOGAN LOBLEY, ESQ., F.G.S.

(*Report by* WILLIAM FAWCETT, ESQ., B.SC.)

This Excursion was the first of a series of five, arranged for the purpose of enabling the Members of the Association to make themselves acquainted with the physiography and the geology of the country between the London Tertiary Basin and the Summit of the Weald. The Series was as follows: First, Orpington to Knockholt; Second, Knockholt to Sevenoaks; Third, Sevenoaks to Tonbridge; Fourth, Tonbridge to Tunbridge Wells; Fifth, Tunbridge Wells to Crowborough Beacon.

A large party of Members met at Orpington, which is situated on the edge of the London Tertiary Basin.

Just outside the station, Mr. Lobley pointed out an exposure of Thanet Sands, the lowest member of the English Tertiaries, and, at a little distance, a good section of the Chalk, the uppermost of the English Secondaries. The presence of Chalk is clearly indicated by the altered character of the country from this point to Knockholt. The bottoms of the Chalk valleys are here covered by ten or twelve feet of gravels and wash of Pleistocene age, seen on this occasion in an excavation for new wells for the Kent Water Company close to the railway bridge. The road now runs along the bottom of the remarkable valley which is but a continuation inland of that of the Cray, but streamless from the absorbent character of the Chalk.

Arriving at Green Street Green, a fine section of Valley Gravels was pointed out, showing an increased thickness of this deposit, fully twenty feet being here exposed. After passing through the village, the ascent of the Downs was commenced, and the party speedily reached higher ground commanding a view over a large area. Mr. Lobley remarked that, instead of the ordinary appearance of sheep-walks in a Chalk country, we here meet with woods and cultivated fields. This is due to the presence of superficial deposits of clays and gravels, the remains of the Tertiary beds once covering the Chalk. After passing Sir J. Lubbock's Park, High Elms, the

road led over the upland towards Cudham. On the right is a beautiful example of a Chalk valley, with its steeply sloping sides and streamless bottom.

From Cudham the Downs were crossed, by Lutt's Green, to Knockholt village. From Knockholt Beeches, 783ft., there is a most extensive view, showing the physiography of the country from London to near Tonbridge. Looking towards London, the Crystal Palace was visible on the high ground of the London Tertiaries ; and to the south-east, the range of Lower Greensand hills on which Sevenoaks is built ; and, further on, the hills of Hastings Sands. With the Survey maps of the entire Wealden area spread out before them, the Members were reminded by the Director of the chief geological features of this remarkable district, which was a great "valley of elevation," the centre being high ground but formed of lower geological beds, and the outer ridge consisting of the ranges of Chalk hills called the North and South Downs, on one of the highest points of which they were now standing. They would cross the various formations in descending order and ultimately arrive at a point on the anticlinal axis of Ashdown Forest, Crowborough Beacon, which may be called the summit of the Weald. It was thus seen that the country to be traversed consists of several parallel clay valleys, running east and west, and separated by ridges of harder rocks, which have their longer slopes on the northern side, and their escarpments on the southern, the dip of the beds being to the north. Though the great valley runs east and west the drainage is by four rivers running to the north and four running to the south, through breaks in the bounding ranges of Chalk hills. This is explained by supposing that as the Wealden district gradually rose above the sea, the waves planed it down almost to a level—Ramsay's "Plane of Marine Denudation," ; the upheaving force, acting along a line running east and west, would cause a slope towards the north and south, and thus determine the direction of the primal drainage. It is a disputed point whether the first beginnings of the present gorges were lines of weak resistance in the upheaval, or whether they were not plications—crumplings caused in the crust by the internal force. The present great valleys running east and west, that, for instance, between the North Downs and the Lower Greensand on which Sevenoaks stands, and the one between the

latter and the high ground of the Tunbridge Wells Sand, were formed by the denudation of the clays, and hence arose these side valleys, with streams which flow into the primary rivers flowing north and south.

The party returned to London from Halstead Station.

EXCURSION TO WATFORD.

SATURDAY, MAY 17TH, 1879.

Directors: WILLIAM WHITAKER, ESQ., B.A., F.G.S., Geological Survey of England; and JOHN HOPKINSON, ESQ., F.L.S., F.G.S., Hon. Sec. Watford Nat. Hist. Soc.

(*Report by* THE DIRECTORS).

A large party, consisting of members of the Association and of the Watford Natural History Society, assembled at Bushey Station at 3 o'clock, and proceeded at once to the Colne Valley Waterworks, near the station, where Mr. Philip Verini,* the Secretary of the Company, showed the party round the works, explaining the method of pumping and softening the water.

The main building was first entered, and here two horizontal steam-engines, each of 60-horse-power, were seen. The engine at work was pumping water from the well below, and at the same time drawing water from the softening tanks outside, and forcing it into the reservoirs on Bushey Heath. The shaft below the engine has a lining four bricks thick for 70 feet, to guard against the inflow of surface-water, and water from the River Colne. Below this there is a boring for 140 feet, and the entire depth, from the floor of the engine-house, 25 feet above the mouth of the shaft, is therefore 235 feet.

A low circular building, called the slaking room, was next entered, and here are large cauldrons in which lime is crushed by a

* It is with much regret we have to record the death of Mr. Verini, which occurred on the 18th of November. To his zeal and energy is mainly due the successful accomplishment of a work which is conferring immense advantage on the district it supplies.

small hydraulic machine. From these are tubes through which the slaked lime passes into larger tanks where lime-water is made.

The method of working adopted in the slaking room having been pointed out by Mr. Verini, the rationale of the process was explained by Dr. John Evans, F.R.S. It is known as Clark's process, by which chalk is expelled, or deposited, from water by chalk. Caustic lime is mixed with water, and the lime-water thus formed being injected into the water pumped up from the well, which contains 16 or 17 grains to the gallon of bi-carbonate of lime, causes the greater part of this to combine with it, so as to form a simple carbonate which, being insoluble, is quickly deposited at the bottom of the softening tanks, leaving the water with only 5 grains to the gallon of the bi-carbonate of lime.

The lime-tanks were then visited, one of which was in use and had at the bottom from three to four feet of lime from the slaking cauldrons. On valves being opened, soft water from the reservoir, at 300 feet higher level, forces itself through a series of holes in long tubes which are placed one foot apart at the bottom of the tank, and by passing through the slaked lime is converted into lime-water. This is then carried by a pipe into the softening tanks outside, which the Members next visited.

After a vote of thanks had been accorded to Mr. Verini, the Members left the water-works for the adjoining chalk-pit, where, after a few fossils had been found, Mr. Whitaker gave an explanation of the section, of which he had published a short description 15 years ago (when probably it was not in such good condition as now), somewhat as follows:—

Ochreous sandy gravel, partly in pipes.

Clay, bluish-grey at top, the rest light-grey, with a layer of a claret-colour at the base.

Chalk with flints.

Deposited on the Chalk very irregularly was, he said, a bed of clay, the lines of bedding of which were waved. The chalk was evidently cut out in a hollow before the clay was deposited, showing a very great interval of time between the deposition of the chalk and of the clay above. Elsewhere such hollows were nearly always caused by the sinking of the overlying beds through the dissolving away of the chalk. The clay could not be older than the Glacial Drift,

and he was inclined to class it as Glacial, though Dr. Evans and other geologists believed it to be Post Glacial. The mistake was often made of supposing all beds termed "Glacial" to be considered by geologists as having been deposited by ice or in an arctic climate, but all that was meant by the term (as expressive of geological age) was that such beds were deposited during the Glacial epoch, in which were intervals of warmer climate as well as cold periods. The bed now seen looked like some beds of brick-earth which elsewhere occurred under Boulder Clay, and it might have been formed in some lake of no very great extent. On the top of this clay might be seen a bed of gravel, but he could not say whether it was a river-gravel or a glacial gravel. If it belonged to the Glacial period, the beds of clay below must also be glacial. Glacial and Post Glacial were, however, only relative terms, for glacial conditions lasted longer in the North of England than here.

On leaving the chalk-pit the road past Bushey Station was taken, and from an elevated position above Wiggenhall, affording a good view of the valley of the Colne and the hills on either side, Mr. Whitaker pointed out the connection of the superficial features of the country with its geological structure. The range of hills on the edge of which we now stood was, he said, known as the Tertiary escarpment; the term "escarpment" meaning a ridge along which the beds were "cut off." These Tertiary beds once extended much further over the county, and the escarpment was at one time beyond its present position, as shown by outliers of the London Clay and Reading Beds. The Colne had most probably determined the present line of the escarpment by cutting its way back, but further down it had turned southward, and cut across the beds. The slope on the opposite side of the valley rises gently to a corresponding elevation to that on which we were, and we should find that this ground consisted of gravel flats of the same character as the one we had just walked over, the river having cut away the beds between.

The valley of the Colne was then crossed, and at the Colney Butts gravel-pits Mr. Whitaker stated that the gravels seen belonged to the Glacial Drift and were probably of marine formation, for in some places, as in Suffolk, marine fossils were found in sandy beds of similar age (older than the Boulder Clay). The larger stones, perfectly rounded, must have come from the north;

the pink quartzites were supposed to have come from the Lickey Hills; and the flint-pebbles had come from Tertiary beds, in which they had originally been deposited after the denudation of the Chalk in which the flints were first formed—a vast quantity of chalk having been denuded to form such extensive gravel beds.

The Hagden Lane gravel-pits were next visited, and here the irregular surface of the Chalk under the gravel was well seen. In continuation of his demonstrations of the geology of the neighbourhood, Mr. Whitaker remarked that all gravels tended to form flats, very nearly level, whenever, as here, there was a large extent of gravel of any age. The gravels here, which belonged to the same sheet as those last seen, were noteworthy as showing no lines of bedding. The very uneven surface of the Chalk seemed to be due to its disintegration, by water, holding carbonic acid in solution, percolating through the gravel above; and the gravel last seen, where not let down by this disintegration of the chalk, was not more than 20 feet in thickness, being comparatively insignificant in section though occupying large areas.

Before leaving the pit a vote of thanks was accorded to Mr. Whitaker, and on the way to Watford Station the members of the Geologists' Association and a few members of the local Society had tea at Wansford House, the residence of Mr. Hopkinson.

EXCURSION TO KNOCKHOLT AND SEVENOAKS.

SATURDAY, MAY 24TH, 1879.

(Second of the Weald Series.)

Director—J. LOGAN LOBLEY, ESQ., F.G.S.

(*Report by* WILLIAM FAWCETT, ESQ., B.Sc.)

The weather on this occasion was inviting, and the country beautiful and interesting. Members assembled in good force. Starting from Halstead Station, the route lay through Halstead Place Park, by the "Beeches" again, through Lord Stanhope's Park, Chevening, Chipstead, Riverhead, and Sevenoaks. At Halstead Mr. Lobley showed how much more complete had been the denudation than about Cudham; here there is but little soil, or valley

gravels. The Chalk has bands of flints, characterising it as Upper Chalk.

From Knockholt Beeches there is an easy descent through the woods of Chevening Park, down the Chalk escarpment, until suddenly there bursts upon the view the beautiful Gault valley in which Lord Stanhope's house is situated. Universal were the exclamations of admiration. The tints of the leaves almost rivalled anything to be seen in autumn, for the oak loves the clay, and here it was to be seen in profusion, mingling its hues of brown with the fresh green of the beech, which favours the Chalk, and the darker shades of the chestnut and holly.

At Chipstead Tile Yard, Pleistocene Brick-earths are seen overlying the Gault clays. They are both worked and often mixed. Here in the Gault are found *Am. interruptus*, *auritus*, and *lautus*, *Belemnites minimus*, and *Inoceramus concentricus*; but *Am. splendens* was not seen, though it is a characteristic fossil of the Gault elsewhere. From the blue Gault clay are made red bricks and dark tiles. The redness is due to the peroxidation of the iron of the clay by the burning, and the dark colour is produced by the oxide of manganese being mixed with the clay. Iron is plentiful in the Upper and Lower Greensand and Gault, but there is little in the Chalk, and that chiefly in the form of sulphuret or iron pyrites. From the tile-yard the way lay across the bottom of the valley, and over the infant Darent to Chipstead village, where the Lower Greensand, which forms the hilly and beautiful ground to the south begins to rise and form the southern side of the valley. This having been traversed for half-a-mile the village of Riverhead was reached, and the party then dined at the Amherst Arms Hotel.

At Riverhead the Folkestone Beds of the Lower Greensand are exposed, of a foxy-brown colour; but they are better seen in the quarry at the Bat and Ball Station, Sevenoaks. In this latter place the sand is loose, the grains only being cemented together here and there in thin irregular layers of ferruginous sandstone. These layers at first sight give the appearance of false bedding, but Mr. Lobley was of opinion that they were not due to that cause. He pointed out the "Box-stones," large irregular ferruginous concretions, or rather shells, with loose light-coloured sand in the middle, many of them being of very considerable size. They are

very dark in colour, and so hard are the shell-like exteriors that they are used for road material. Some good specimens having been secured, the party proceeded to the Tubs Hill Station, and, while awaiting the train for London, noted the grand exposure of the Hythe Beds of the Lower Greensand here seen, but which was reserved for more extended observation at the next Excursion of the Series.

EXCURSION TO BATH.

WHIT-MONDAY, JUNE 2ND, 1879, AND FOLLOWING DAY.

Director—CHARLES MOORE, Esq., F.G.S., Hon. Memb. Geol. Assoc.

(*Report by* MR. CHARLES MOORE).

The Whitsuntide Excursion, which was fixed for Bath, and which promised to be one of the most agreeable and interesting of the year, was unfortunately marred by unpropitious weather, there being an almost continuous downpour of rain during both days.

The Members were met at the railway station by their Director, Mr. Charles Moore, F.G.S., and, after necessary hotel arrangements, accompanied him to the Free Museum, of which he has been the founder. On arrival there, Mr. Moore informed his audience that the fine room in which his collection was located had been placed at his disposal for its reception 27 years ago by the Committee of the Literary and Scientific Institution, and that during that period it had been entirely under his own supervision, unaided by any public or private funds, except that when, in consequence of the growth of the collection, no more space being available, a generous contribution from Mr. Handel Cossham, F.G.S., enabled him to place a gallery round the Museum, considerably extending its table and wall-space. In speaking of its contents, Mr. Moore remarked that his visitors would at once observe the fine series of reptilian remains arranged on the walls, and that, including others that would be found in the table-cases, there were not less than forty-three more or less perfect examples in the collection, in the pleasurable development of all of which his hammer and chisel had alone been employed.

It would be seen that the collection was a general one, and stratigraphically arranged, but it was chiefly illustrative of the geology of Somersetshire and the South-west of England. His geological experience had fortunately been acquired in a district which presented a greater geological variety than any other in England, for, included within the county, with but few exceptions, were the representatives of nearly all formations, from the Old Red Sandstone upwards.

On examining the table-cases, it would be seen that there were scattered throughout them a considerable number of lithographic drawings, attached to the tablets. Where this was the case, they indicated new or typical species, which had been figured and described from his collection. In the course of a single visit it would be impossible for him to do more than refer to a few of the special features of the collection, and these, excepting a fine series of plant remains in the gallery from the Somersetshire Coal-beds would be from Secondary formations, or included, as their programmes showed, in the beds from the Trias to the Upper Lias.

Although there were many sections in the districts of Glastonbury, Somerton, Langport, &c., especially in the escarpments fringing the moorlands, where the Keuper Beds are to be seen, they presented but few well-marked lines of division, which chiefly arose from their being principally composed of variegated sands and marls. The only really satisfactory recorded section was one given by William Smith, from a boring made for coal at Compton Dundon, in the year 1815, which reached a depth of 600 feet. There had as yet been no evidence of the presence, in this country, of the Hallstadt and St. Cassian Beds, which succeed the Keuper on the Continent, and the latter therefore graduates somewhat insensibly into the Rhætic Series, to be followed by the Lower Lias, which, though very thin in the Bath district, attained to the west at least 600 feet in thickness. As none of the Rhætic beds excepting the "White Lias," are worked for economic purposes, the precise passage of these beds might have been somewhat uncertain, but for the railway sections made through them at Hatch, Sparkford, Shepton Mallet, Willsbridge, and several others, including Weston, near Bath, where was an admirable section of the White Lias, to which he hoped to take them during the day.

Before referring to the fauna of the Somersetshire Trias, Mr.

Moore exhibited a block containing a *Rhynchosaurus*, from Grinshill, near Shrewsbury, which was but partly worked out. It was in so dense a matrix, and the bone itself was so fragile, he feared he could do no more with its development. It was the first time he had been beaten by a fossil.

Notwithstanding the great thickness of the Keuper Beds, there are but few horizons that yield organic remains, and these belong chiefly to scattered Vertebrata. With this exception he had only found besides plants and *Estheria*, a single cast of a *Modiola*, and a derived encrinital stem, which showed how inimical must have been the physical conditions of this period to the life of the Testacea.

Respecting Keuper Vertebrata, he had been more fortunate. In an excavation in the variegated marls, for the foundations of a house at Ruishton, he observed a thin layer of sandy conglomerate, and the result of an investment in a load of it which was sent to Bath, was the series of remains in the case before them. Amongst these were teeth of *Thecodontosaurus* and *Palæosaurus*, *Batrachia*, *Sphenonchus* and *Diplodus*, with their curved fangs, and allied to them a form with three much recurved teeth, which had not before been noticed, and which might be named *Triplodus*. It is probable that the Budleigh Salterton, and Sidmouth red marls, which also contain vertebrate remains, occupy a lower position in the series, and that those of Ruishton are on the horizon of the Pendock and Warwickshire Keuper. From the sandy and unconsolidated character of the Ruishton bed the fossils are exceedingly brittle.

In the table-case following the above, are the wonderful series of remains from the Holwell Rhætic drifts, which were found in friable marly deposits caught up in veins of Carboniferous Limestone. Samples of the matrix were placed in the case. If his visitors had passed the three loads at which he had worked by the roadside, they would most likely have been set down as road-scrapings. There were in the case thousands of fragmentary and worn bones, and including others, and mammalian, reptilian and fish teeth, hundreds of thousands more perfect. As many of these were of small size, Mr. Moore exhibited enlarged drawings, with about 200 figures of detached bones and teeth represented in the series. The teeth of *Microlestes Moorei*, Owen, and *M. antiquus*, Plen., were inspected, and illustrated by a recent head of the little kangaroo, *Bettongia*, from Australia. Mr. Moore pointed out three toe bones

of a large dinosaurian reptile, allied to *Scelidosaurus*, which were found in the regularly stratified Rhætic marls, and amongst others of interest, to the teeth of *Thecodontosaurus* and *Palæosaurus*, genera which had been found many years before in conglomerate on Durdham Down, also associated with Carboniferous Limestone. It was specially pointed out that, although the same *genera* of Vertebrata were found in the Keuper and Rhætic beds of this country, the *species*, with few exceptions, were quite distinct, and it was still more doubtful if any from the latter beds passed into the "White Lias," or into the "Lower Lias" above. In his experience of forty years, no reptilian bone had ever been found in the White Lias, and though several small fish had been met with in the "landscape-stone" of Bristol, he had never found more than one solitary fish bone, though such countless numbers must have existed to have formed the bone-bed but a few feet below. Changes in the physical condition of the deposits probably accounted for their absence in the White Lias. Following the Vertebrata, the typical Mollusca of the Rhætic Series, figured and described by Mr. Moore, were noticed, and the paucity of their remains in the White Lias also referred to.

The organic remains from the Lower Lias next followed, amongst which were many new species, but he should only ask their attention to the new Corals, and to the Reptilia. Only six or seven species of corals were known a few years since in the whole of the Liassic series, until he was fortunate enough to go into a small Carboniferous Limestone quarry at Brocastle, South Wales. On the top of the limestone he recognized a thin band of Liassic conglomerate, which, in addition to other remains of interest, eventually yielded him thirty-five species, which had been described by Dr. Duncan, F.R.S., in the Palæontographical Society's Proceedings, for 1866. They would see the lithographic illustrations alongside the specimens. Amongst the Reptilia he need scarcely direct their attention to the gigantic head of *Ichthyosaurus platyodon*, probably the finest known. The head alone weighs 12 cwt. Over this head there is a small *Ichthyosaurus communis*, the whole of whose stomach is coloured by a black pigment. The fact was that the *Ichthyosauri* fed upon contemporaneous cuttle fishes, and this black matter formed the contents of their ink-bags. He could trace it in nearly every specimen. They would get evidence of this again directly.

Passing the several horizons of the Middle Lias, he would introduce them at once to the wonderful contents of the Upper Lias saurian and fish-bed, which, though averaging less than a foot in thickness, had yielded him material sufficient to fill eleven compartments of his table-cases. It appeared to have been formed by the irruption of fine mud into an estuary which apparently killed off all its inhabitants. The Reptilia and other larger remains are found in elongated disjointed septaria, just covering up, and still assuming the shape of the enclosed organisms. No pressure appears to have been subsequently applied to them, as they are still uncompressed, and even the stomachs of some of the Reptilia remain unconsolidated. Two species of *Pelagosauri* (*Teleosaurus*) occur, the *P. Moorei*, Desl., and the *P. typhus*. In a beautiful specimen of the former species, only thirteen inches long, a *Leptolepis constrictus* lies undigested in its stomach, and the rugose skin of the *Ichthyosauri* fringes the line of their skeletons, whilst these too considered cuttle fish dainty morsels. Passing on to the case containing the cuttle fishes, it was pointed out that, in every instance, the ink-bag was present, and still retained the dry remains of its once inky fluid. The fine series of fishes belonging chiefly to species of *Pachycormus* and *Lepidotus* next came under review, as well as *Ammonites* with their *Aptychi*. The bed contained Crustacea and many insects. The latter were in the hands of Mr. Goss, who, having given valuable contributions to the "Proceedings of the Geologists' Association" on this family, had promised one on his collection. Want of time only permitted slight reference to the many typical Brachiopoda in the museum, and to the Post-Pliocene remains from the gravel of the Bath Basin and the adjoining valleys.

A visit was paid to the Abbey and to the bathing establishments, the waters drank, and baths next morning taken by some Members of the Association.

Instead of proceeding by railway, as had been proposed, to Vallis and Holwell, it was determined to go by road, as it would better indicate the physical character of the country passed through.

Under the area in Bath occupied by the Roman city, there has been an accretion of ten or twelve feet of material above its foundations, and under this follow mammal drift gravels and alluvium,

all of which rest on the lower members of the Lower Lias. In passing from the latter formation up the southern escarpment to the table-land of the Great Oolite on Combe Down, at an elevation of 600 feet, the edges of the Middle and Upper Lias, Inferior Oolite, Fuller's Earth, and Great Oolite, have been crossed, though no sections are visible, except in the Great Oolite on the Down. A fault passing through the Bath Valley has placed these beds about 200 feet lower than on the northern side of the city. In less than a mile from Combe Down, the narrow Midford valley, through which the railway to Radstock passes, is crossed, and the above beds again repeated on either side. In this valley are several sections to which the term Midford Sands has been applied, but they are very insignificant as compared with their greater thickness in the Yeovil and West Somerset districts. Looking down from the table-land, the position of the Radstock Coal Basin was seen, and beyond the uplifted range of the Old Red Sandstone, and the Carboniferous Limestone of the Mendips, the eastern end of which it was the object of the party to reach, stood out boldly in its passage through Somersetshire.

On arrival at the Hapsford Mills end of the Vallis ravine, Mr. Moore gave a descriptive notice of each of the sections, and the peculiar varieties the beds presented above the Carboniferous Limestone, for which they were formerly worked. At the base were conglomerates representing the ancient coast-line of the Rhætic seas, containing scattered fish remains and Reptilia, and mixed up with them patches of clays containing *Avicula contorta* and limestones, with occasional insects, and the little brackish-water crustacean *Estheria minuta*. Above these were traces of the Lower Lias, and then to the surface six to eight feet of Inferior Oolite. Several Secondary veins with organisms, passing down through the Carboniferous Limestone attracted attention.

For some time the unpropitious state of the weather had rendered it a "pursuit of knowledge under difficulties," and it was determined to defer to another opportunity a visit to Holwell, two miles beyond—the hunting-ground of the Rhætic kangaroo.

ORDINARY MEETING.

JUNE 6TH, 1879.

Prof. J. MORRIS, M.A., F.G.S., Vice-President, in the Chair.

The Donations to the Library since the previous meeting were announced, and the donors received the thanks of the Association.

The Following were elected Members of the Association :—

Thomas Cole, Esq., Assoc. Inst. C.E.; A. Jesseman, Esq. ; and Richard D. Poppleton, Esq.

The following Paper was read :—

ON THE AGE OF THE PRINCIPAL MOUNTAIN CHAINS OF THE GLOBE.

BY J. LOGAN LOBLEY, F.G.S., F.R.G.S.

EXCURSION TO SEVENOAKS AND TONBRIDGE.

SATURDAY, JUNE 14TH, 1879.

(Third of the Weald Series.)

Director—J. LOGAN LOBLEY, ESQ., F.G.S.

(*Report by* WILLIAM FAWCETT, ESQ., B.SC.)

Members left the train at Dunton Green for the purpose of inspecting the excavations in the extensive Brick-yards of Mr. W. J. Hooker, who courteously gave every facility for the observation of the sections and the collection of fossils. Those excavations afford a good display of the Gault seen on the 24th May at Chipstead; it extends E. and W. for many miles along the base of the escarpment of the North Downs, forming the beautiful Vale of Westerham. Both the Gault, and the Pleistocene Brick-earths which cover the Gault in places along the valley, afford here materials for bricks and tiles.

After crossing the alluvium of the Darent Valley, and the stream

itself, the Folkestone Beds of the Lower Greensand were found exposed in a field near Riverhead, through which village the party then proceeded to the Tub's Hill (Sevenoaks) Station. Between the station and the tunnel there is a fine section, about 90ft. high, showing the Hythe Beds of the Lower Greensand, and yielding abundance of *Gryphæa sinuata*. The Association were afforded every facility for examining this section by the courtesy of Mr. Shaw, the Manager of the South-Eastern Railway. Mr. F. Drew* gives the following description of the beds on the coast of Kent:—"The Hythe Beds are interstratifications in about equal proportions of limestone and sand. The former is close in texture, has a grayish blue colour, and contains fine grains of quartz; the latter is for the most part drab-coloured, impure, rather clayey, and somewhat calcareous; the stone goes by the name of 'rag,' while the intermediate sandy beds are called 'hassock.'" At Sevenoaks the distinction is not so great; the hassock is harder, is in a larger proportion than the rag, and both are used for building. The Sandgate Beds, intermediate between the Folkestone and Hythe Beds, are here wanting, whereas at Folkestone all three are developed. A good example of a "fault," and a remarkable anticlinal dip of the beds, were noted near the entrance to the tunnel. The Folkestone Beds cover the Hythe Beds, and form the high ground on which the town of Sevenoaks stands. The junction was seen by the party as they ascended from the railway cutting and made their way to Sevenoaks. A brief visit was paid to Knole Park, in which the beautiful country formed by the Lower Greensand of Kent is well exemplified.

After dinner at the Royal Oak Hotel, the party proceeded along the road to River Hill on the escarpment of the Lower Greensand, commanding a fine view over the second of the great east and west valleys. At the bottom of the hill is the Atherfield Clay, then the broad expanse of Weald Clay, with the Medway meandering through it. The road through Hildenborough was taken, and after a brisk walk across the Weald Clay vale, rich with hop gardens and orchards, Tonbridge was reached, standing on a superficial deposit of Alluvium of the Medway.

The party returned to London from Tonbridge Junction.

* Quoted in Topley's "Weald," p. 116.

EXCURSION TO TONBRIDGE AND TUNBRIDGE WELLS.

SATURDAY, JUNE 28TH, 1879.

(Fourth of the Weald Series.)

Director—J. LOGAN LOBLEY, ESQ., F.G.S.

(*Report by* WILLIAM FAWCETT, ESQ., B.SC.)

A large number of the Members of the Association met at Tonbridge to inspect the country from Tonbridge to Tunbridge Wells.

On the way to Southborough, Mr. Lobley pointed out the main features in the physical geology of the country, and the various strata to be met with. Tonbridge town is situated on the Alluvium formed by the Medway, the station is on the Tunbridge Wells Sand; and at the Hastings Road is first seen the Wadhurst Clay, which extends to Quarry Hill. The Ashdown Sand at Quarry Hill, thrown up by a fault, is interesting, as it is the lowest member of the Wealden group. A short distance after passing the Mabledon Lodge we again come upon the Wadhurst Clay, succeeded at the Penshurst road by the Tunbridge Wells Sand, which extends beyond Tunbridge Wells, with outliers here and there of the Weald Clay. At one of those points on the road from which a view may be had of the valley of the Medway, Professor Morris spoke of the difficult question of the origin of the Medway gravels. These gravels occur at various heights above the present bed of the river, up to as high as 300 feet. It is remarkable that in no part of the Weald are gravels found at any great distance from the margins of streams; and hence it is inferred that they have been laid down by rivers actually running in the same courses as at present. The gravels along the upper stream of the Medway consist only of Wealden pebbles, but, on the banks of the Eden, the western tributary of the Medway, they also contain flints and Tertiary pebbles. The Eden joins the Medway at Penshurst; from that point, onwards, the gravels combine the characters of the upper Medway gravels and the Eden gravels, until the Medway has passed well out of the Weald country, and then the Wealden pebbles disappear. Again, the

gravels of the Beult and Teise, the eastern tributaries, joining the Medway at Yalding, are composed of Wealden pebbles. Now when it is seen that the Upper Medway, the Beult, and Teise, and their feeders, drain Hastings Beds, and that the Eden runs down from the Chalk escarpment, it appears difficult to explain the composition of the gravels on any other hypothesis than that adopted by the Geological Survey, viz., that the gravels were formed by rivers running in the same courses, and (contrary to the theory of Mr. S. Wood, jun.) *in the same direction* as at present. One difficulty at first sight is that the Wealden pebbles disappear in gravels near the mouth of the Medway, but this is explained by saying that the *débris* of the Wealden Beds, either entirely disappear almost as soon as formed, as in the case of the calcareous "Rag," or are of a character so soft in comparison with flints and Tertiary pebbles, that they soon wear down from pebbles into sand. There appears, then, to be proof that rivers have excavated valleys to the depth of at least 300 feet. It is impossible to say how much more river erosion had taken place before these highest gravels were deposited, but if it was as much as 300 feet, that amount would account for the whole of the subsequent denudation of the original "plane of marine denudation"; that is to say, all the present configuration of the country, the hills and valleys, are due to the action only of rain and rivers. Certainly there is no evidence of any other agency; there are no raised beaches, the result of marine denudation, no drift left by tidal erosion, no moraines by glaciers.

At Southborough, lunch was provided at the Hand and Sceptre Hotel, and the arrangements made seem to have given general satisfaction. After a visit to Pennington Lane, which affords a grand view over the Medway valley and some of the richly-wooded lateral valleys, the party proceeded towards Tunbridge Wells.

On the way, Mr. Lobley pointed out an outlier of the Weald Clay at Mrs. Newnham's brickfields. Arriving by Mount Ephraim on the famous and beautiful Common, the higher valleys of the district were seen, and the summit of the Weald, Crowborough Beacon, at length bounded the view. The Tunbridge Wells Sand is conspicuously displayed in the picturesque "rocks" which stud the higher parts of the Common near Mount Ephraim. The sand is so well compacted that soft sandstone rock is the result, and, where it is harder than elsewhere, greater resistance to weathering

has given outstanding masses, some most grotesque in form and appearance.

Permission was kindly given to visit the charming grounds of the Spa Hydropathic Establishment, which fronts Bishop's Down at the eastern extremity of the Common. In the grounds may be seen a good specimen of the beautiful little valleys which abound in the neighbourhood, and which, with the fine timber adorning both hills and valleys, render this district so attractive.

A little further to the east the Tunbridge Wells Sand is again characteristically seen on Rusthall Common, where the rocks are still more striking than at Mount Ephraim. One of these masses has received the name of the "Toad Rock," from its resemblance to that animal, and others, too, are known by distinct names. They are fine examples of rocks of various degrees of hardness, acted upon by atmospheric agencies.

Leaving Rusthall Common, the party crossed the "Happy Valley," having Wadhurst Clay in the bottom, to the well-known "High Rocks," again showing Tunbridge Wells Sand, here thrown up by a fault. After inspecting these huge masses of soft sandstone, with their remarkable clefts, Members made their way by the narrow valley along which runs one of the feeders of the Medway, the boundary between Kent and Sussex, to Tunbridge Wells Station, for the return to London.

ORDINARY MEETING.

JULY 4TH, 1879.

Prof. T. RUPERT JONES, F.R.S., F.G.S., President, in the Chair.

The Donations to the Library received since the previous meeting were announced, and the donors received the thanks of the Association.

The President having left the chair, it was taken by Prof. J. MORRIS, M.A., F.G.S., Vice-President, when

The following Paper was read:—

On the Nature and Origin of Peat and Peat-bogs.*

By Prof. T. Rupert Jones, F.R.S., President Geol. Assoc., &c., &c.

Abstract; with Additions.

Contents:—

§ I. This paper began with a description of Peat and Peat-bogs, noticing the former as a more or less brown or black, carbonized mass of vegetable matter, accumulated by the growth of plants in moist situations, either on high or low ground, mostly in temperate climates,† and presenting various muddy, spongy, and fibrous con-

* A paper by the author on the same subject is published in "Science for All," Cassell & Co., No. 23.

† The "*Dismal Swamp*" is a morass in the United States of North America, commencing south of Norfolk, in Virginia, and extending 30 miles into North Carolina. Area about 235 square miles. It is thickly covered with wood, has Lake Drummond in its centre, and is traversed by the Dismal-Swamp Canal, 23 miles in length.—K. Johnston's "Gazetteer." The Peat-deposits of Calcutta and Nepâl are noticed by the Geological Surveyors in the "Indian Survey Records," and the "Manual of the Geology of India."

ditions, at different depths in the mass, or at different places of accumulation.

Bogs, Mosses, Turbaries, &c., were described as continuous or broken, flat, marshy, muddy, peaty, and watery tracts, here and there firm enough, either by a local rising of the soil, or with the tough entanglement of vegetable roots and fibres, to bear animals and men, but often dangerous sloughs, marked with a green coating of Bog-moss and other aquatic plants.

Walter Scott's description of the home of a Moss-trooper indicates these features with graphic force :—

"The ground upon which it (the tower) stood was gently elevated above the marsh for the space of about a hundred yards, affording an esplanade of dry turf, which extended itself in the immediate neighbourhood of the tower; but beyond which the surface presented to strangers was that of an impassable and dangerous bog. The owner of the tower and his inmates alone knew the winding and intricate paths, which, leading over ground that was comparatively sound, admitted visitors to his residence."

—"The Black Dwarf," Chap. viii. And in another instance ("Lay of the Last Minstrel," Canto iv.)—

"He led a small and shaggy nag,
That through a bog, from hag to hag,*
Could bound like any Bilhope stag."

Peat has been described in very many books and memoirs, as to its formative plants, its chemical constituents, and its economical uses. In this paper the conditions of accumulation, and the kind of vegetation concerned, were chiefly treated of; it being specially insisted on that "on both plateaux and plains, every gradation from puddles and ponds to lakes, and from marshes and fens to bogs, is found wherever the ground, being flat and impervious, can hold water on its surface." A ferruginous crust (called "Alois"), lying underneath sands in the Landes, near Bordeaux, stops the soakage of the water, and makes marshes ; hence the common use of stilts there: and in Jutland, the "Jern-al" (iron-sand), from 2 to 4 feet thick, is a similar formation. See Reclus "Le Terre," Woodward's English Translation, 1871, p. 84 and p. 86.

At the bottom of the peat at Windlesham, near Bagshot, Surrey, 4 or 5 inches of porous limonite (bog-ironore) have been locally accumulated by the infiltration of irony water; just as the hard "Pan" or "Rust" is formed under gravel, stopping water and

* "The broken ground in a bog."

roots, to the injury of vegetation, until it is broken up in trenching the ground for cultivation.

In the "Geologist," 1863, Vol vi., p. 114, is an abstract from "Hameberg's Journal," of Dr. Mega's account of a kind of "Pan" in the heaths of Hannover in America, which is a hard and tough "peat-sandstone," that is, a quartzose sand cemented by peaty material by means of the bog-water.

The occurrence of clay under peat has often been noticed—see for late instances Dakyns, "Geological Magazine," Ser. 2, Vol. vi., p. 47; and T. R. Jones, "Transactions Newbury Field Club," Vol. ii., p. 132 *note*.

The growth of Alpine Mosses and Rushes in moist hollows, in tarns and other upland lakes, supplies both living and decomposing plant-material, which gradually takes the place of shallow water; and the streams have the brown or amber-coloured tint of bog-water in consequence. At lower levels, lakes, shelving river-banks, deserted river-bends, and maritime flats are invaded, and ultimately become choked by marsh-plants, that is—such as flourish either in the water or on wet ground. So also in cultivated lands, the ponds, old canals, ditches, neglected cuttings by the side of railways, and such like, are soon colonized, and in time wholly occupied, by similar water-plants. In turn, the areas of many natural lakes and of old beaver-ponds, replaced by peaty formations, are either used for the extraction of peat for fuel, or are drained and cultivated by modern agriculturists.

§ II. In the natural process of Peat-formation, there are—

(1.) Waterside plants, encroaching on the shelving mud, whether this be a deposit from flood-water, or formed of the soft clays of the lake- or river-bed.

The flora which mainly contributes, in our latitudes, to the formation of Peat has been noticed more or less fully by numerous writers. A list is given in APPENDIX I.

(2). Plants growing in the water itself, either rooted in the bottom, or floating on or below the surface. All these, as they die, go to make a vegetable deposit, or *Submerged Peat.* This gradually accumulating, and approaching the water-level, becomes an *Emerged Peat*, and affords a floor for the growth, first, of the marginal marsh-plants, and ultimately of such larger herbs, bushes, and trees, as keep their roots in wet ground only. Occasionally *Emerged Peat* takes the form of free floating islands in lakes, or of broad raft-

like crusts, which supply broken and rotten plant-matter to the lake. Such turf-islands or moss-islands have been frequently described :—for instance, those of Derwent Water, by Rennie, "Essays on Peat-mosses," p. 454; of Holland and Wackhusen, *ib.*, p. 461; of the Cleveetz or Beel Lake, by J. F. Julius Schmidt, "Zeitsch. d. d. Geol. Ges.," Vol. viii., p. 494, &c.

Some floating masses originate at the sides of quiet lakes, where creeping Grasses and other plants push off their floating and matted growth from the banks, to be joined by Bog-moss, with the minute fibres of *Conferva*, *Batrachospermum*, *Bulbochæte*, and other filamentous simple plants, and with Duckweed, Watercrowfoot, and such like floating vegetation. Thus turfy masses form at the surface. These, slowly sinking as they fade and decay, are thickened and covered by the growth of other water-plants, and the whole accumulates in time as peaty material in the water.

In course of time, if no change in the local drainage takes place, the mud and sand of floods have aided the marsh-plants, wet jungles, and damp forests, to raise the level still higher; and Man steps in to clear and cultivate the spots most suitable to his requirements.

In the wide shallow hollows on many table-lands and heathy plateaux, whether in the broad upper valleys, or in the natural depressions of the surface, an analogous series of conditions takes place with the local vegetation, which can scarcely form a *Submerged*, but grows at once as an *Emerged* or *Superficial* Peat, and soon coats itself with the entangled tissue of heath-roots and other fibrous material. This undergoes relatively little decomposition, and is best known, in some parts of England, as "Turf."

§ III. Under these circumstances Peat may be classified thus (see "Science for All," No. 23, p. 344)—

"I. Peat-bogs and Turf-moors on such plateaux as flat mountain-tops and wide hill-moors.

"II. Peat-bogs of valleys :—1. At the heads of valleys. 2. At the salient angles within river-curves. 3. In deserted bends of rivers. 4. In plains and lakes of expanded valleys. 5. Special Peat-bogs of Denmark, and the Black-earth of Russia. 6. River-deltas. 7. Maritime Peat-marshes, where certain valleys and plains (which are but broad valleys), open to the sea."

I. In illustration of this division of the subject, (1.) the Highlands of Scotland were alluded to, where the general "turf" of

the higher surfaces passes into "peat" in the hollows.* (2). The Bog of Allen in the hollows of the great limestone flats in the middle of Ireland.

In that country "Turf" (Peat) is said to occupy 2,830,000 acres, or nearly one-seventh of the entire area.†

The Parliamentary Reports on the Bogs of Ireland, 1810, &c., contain much information. The following is the detailed description of a "Section of a Turf-bank in Timahoe Bog, in the Eastern District of the Bog of Allen,‡ in Co. Kildare," as given in "The first Report of the Commissioners appointed to enquire into the Nature and Extent of the several Bogs in Ireland, and the Practicability of Draining and Cultivating them. Ordered by the House of Commons to be printed 20th June, 1810." 4to.

No.	Depth in feet.	
1.	2	Dark reddish brown; mass compact; no fibres of Moss visible; surface of Bog decomposed by the atmosphere.
2.	3	Light reddish brown; fibres of Moss very perfect.
3.	5	Pale yellowish brown fibres of Moss very perceptible.
4.	8½	Deep reddish brown; fibres of Moss perceptible.
5.	3	Blackish brown; fibres of Moss scarcely perceptible; contains numerous twigs and small branches of Birch, Alder and Fir.
6.	3	Dull yellowish brown; fibres not visible; contains much empyreumatic oil; mass compact.
7.	10	Blackish brown; mass compact; fibres not visible; contains much empyreumatic oil.
8.	4	Black mass, very compact; has a strong resemblance to pitch or coal; fracture conchoidal in every direction, and lustre shining. (Depth of Bog, 38½ feet.)
9.	3	Marl; contains 64 pr. ct. of carbonate of lime.
10.	4	Blue clay.
11.		Clay mixed with limestone-gravel. (Depth unknown.)

H. Schinz-Gesner, writing on Peat in 1857, stated that in the great Moors in Bavaria the observed increase of peat in 45 years was 2 to 3 feet; in Oldenberg, in 100 years, only 4 feet; in Hämmelsmoor, Denmark, 2½ feet; and that in Alpine districts peat-pits have been observed to fill 4 to 5 feet in from 30 to 50 years.

* See, for instance, "Geol. Survey Memoirs, Explan. Sheet 24, Scotland," p. 22. Consult also James Geikie's "Memoir on the Peat-mosses of Scotland." (See APPENDIX II.)

† For some notices of the Irish Peat-deposits, see the "Geol. Surv. Memoirs, Ireland," Explan. Sheets 35, 49, 50, 61, 128, 142, 143, 153, &c.

‡ This Bog was also described by Prof. Jukes in the "Quart. Journ. Geol. Soc.," Vol. xviii., p. 379.

The Rev. Mr. Jenyns ("Report Brit. Assoc.," 1845, Sect. p. 75), was informed that in Cambridgeshire the peat-pits filled slowly at the rate of about 20 inches in 16 years. The pits in Speen Moor, Newbury, where *Equisetum* is a predominant plant, are said to fill at the rate of several inches every year (see above, p. 188).

II. (1). As a good illustration of upper-valley Peat, a picture of some mountains, by Crome, in the National Gallery, No. 1,037, entitled "Slate Quarries," was referred to. In this painting the condensing mountain-tops form the background, the lines of drainage are traceable, and the great brown areas of massive peat, with characteristic green patches of deceptive sward-like surface, are noticeable features. Chat-moss on a northern affluent of the Mersey, in Lancashire, was also mentioned.

To this series belongs the small upland lake or pond, choked with peat 14 feet thick, lying on sandy clay, bog-iron-ore, and marly sand, near Kildale, in Yorkshire, as described by Mr. A. G. Cameron, "Geological Magazine," 2nd ser., Vol. v., p. 351.

The bursting of bogs, when the wet spongy mass can no longer hold up by capillary attraction the black liquid mud above the horizontal line, was also spoken of. The model of a burst and sliding bog, near Slamannan, in Lanarkshire, made by Mr. Thomas Gibbs, and deposited in the Museum of Practical Geology, was alluded to.

II. (2 & 3.) The Peat formed at the alluvial tongues stretching into shallow water, opposite to the high and hollow cliffs at the turns of a winding river, was noticed; also the gradual infilling of lake-like waters left when such rivers have cut across the neck of semi-circular bends, and deserted them for the new channel.

Sir C. Lyell ("Second Visit to the United States," Vol. ii., p. 244), writing of the swamps on the alluvial slope of the Mississippi above and below the present head of the delta, states that sand and mud are deposited over the plain by the river and its tributaries, and most of the area consists of swamps, surrounded by luxuriant growths of timber, "interspersed with lakes, which are deserted river-bends. These lakes are slowly filling up, and every swamp is gradually becoming shallower, the substance accumulated in them being for the most part of vegetable origin, unmixed with earthy matter."

II. (4.) The enormous gorges in which the larger valleys originated were due probably to great earth-cracks; and after having

been fashioned by glacial and strong aqueous action, they were gradually choked with blocks, boulders, gravel, sand, and mud from glaciers and torrents, until the now existing alluvial plains were formed. These retain in their present rivers a mere trace of the original tumultuous drainage, which is occasionally imitated by devastating floods. These broad plains are sometimes grassy prairies, or extensive forests; but often they are "swampy flats, varied with desolate peat-bogs, rank cane-brakes, or sedgy moors, all characterised by the dead level of the former water-line." The river-freshets, from rain or snow, sometimes cover the peaty areas, just rising from lakes and backwaters, with heavy loads of gravel and sand; and thus make fresh clear lakes again. These are fit to be inhabited by many generations of freshwater Mollusca, which leave layers of their white decomposing calcareous exuviæ in the "Shell-marl," often seen in cuttings in fens and in drained lakes.* The *Diatomaceæ*, too flourish until thick beds of their microscopic siliceous frustules accumulate as "Mountain-meal,"

* See H. Warburton, "On some Beds of Shell-marl in Scotland," 'Transact. Geol. Soc.,' Vol. iv., 1817, p. 305, &c.; Sir C. Lyell, "On a Recent Formation of Freshwater Limestone in Forfarshire, and on some Recent Deposits of Freshwater Marl," 'Transact. Geol. Soc.,' Ser. 2, Vol. ii., 1826, p. 73, &c.; W. Buckland, "Notice of the Shell-marl in the Valley of the Kennet," in a Memoir in the 'Transact. Geol. Soc.,' Ser. 2, Vol. ii., 1826, p. 128, &c.; W. J. Hamilton, "On the Occurrence of a Freshwater Bed of Marl in the Fens of Cambridgeshire," 'Quart. Journ. Geol. Soc.,' Vol. vi., 1850, p. 451; T. R. Jones, "Lecture on the Geological History of Newbury," 8vo., 1854, p. 40, &c.; "Memoirs of the Geological Survey, Explanation of Sheet 12," 8vo., 1862, p. 47, &c. Shell-marl associated with Peat in Ireland is noticed in several of the Explanations of Sheets of the Geol. Surv. Map. From the grey marl of an old lake-floor in a valley near Apethorp, not far from Stamford, on which a Roman Station (discovered in 1859) had been established, though subject to inundation, the following freshwater shells and other organisms were found by Mr. John F. Bentley. They were named by Dr. S. P. Woodward—

Planorbis nautileus,	Clausilia plicatula?
Pl. spirorbis,	Cl. laminata,
Succinea putris,	Cyclostoma elegans,
Physa fontinalis,	Zua lubrica,
Bithynia tentaculata,	Helicella crystallina,
B. Leachii,	H. cellaria,
Limnæa peregra,	H. radiatula,
L. palustris,	H. lucida,
L. truncatula,	Helix fulva,
Valvata spirorbis,	H. aculeata,
Pupa muscorum,	H. rufescens,
Carychium minimum,	H. hispida,
Vertigo pygmæa,	H. pulchella,
V. pusilla,	H. arbustorum,
V. antivertigo,	H. rotundata,
Cionella acicula,	Candona lucens,
Acicula lineata,	Seed-vessels.

"Polishing-powder," &c. Submerged and emerged Peat again are formed, supplanting the lake; and, may be, land is gradually secured, and a forest-growth in time succeeds. The "Broads" of Norfolk, abounding with water-plants, and choked in places with vegetation, are probably hollows left in old river-valleys of the Post-Tertiary Period.*

The wooded valley-ground, which owed its constitution to the Peat, is time after time inundated by the flooded river, swollen by sudden increase in its head-waters, or checked by landslips, gravel-heaps, fallen timber, and other hindrance to the drainage; or perhaps the forest-fastness of an enemy has been drowned-out by the skilful interference of a destroying conqueror. Then the forests of the river-side, thus swamped, die and rot, and "the spongy Bog-moss, creeping up among their prostrate trunks and branches, raises its water-laden mass of rotten fibres and false green mask above the ancient forest-land" ("Science for All," No. 23, p. 346.)

Thus cane-brakes, jungles, and forests, one over another, are found in Peat-bogs, with or without intervening beds of alluvium and lake-deposits; the overloaded surface having frequently subsided and renewed itself again by the growth of peat. Where the arboreal vegetation has persistently retained the same character, no external change has led to specific differentiation through the long periods of peat- and forest-growths; but sometimes great climatal changes have brought about a succession of faunal and floral characteristics in the slowly passing ages.

Geological evidences of oscillations of level, and changes of superficial conditions have been frequently noted from sections exposed in peat-beds of various kinds. Such sections have been described, for instance, in Shropshire ("Proceed. Geol. Soc.," Vol. ii., p. 200); in South Wales ("Quart. Journ. Geol. Soc.," Vol. xii., p. 169); in Somerset (Vol. xxii., p. 1); Scotland (Vol. xxxiii., p. 196), &c.

II. (5.) "In Denmark, where Peat-mosses abound, there are some of great interest, though of limited extent, which have been formed in caldron-like cavities in the Boulder-clay. These great *pot-holes* are of obscure origin; they may have originated by great masses of ice, or of frozen mud, having been deposited and subsequently melted, letting down the overlying beds; or they may be due to

* "Quart. Journ. Geol. Soc.," Vol. xxv., p. 259.

the Boulder-clay having been laid down over fissures and pot-holes in the rock on which old glaciers had worked, and so sunk down. At all events, they have been the receptacles of lakes, with bed-clays retaining well preserved remains of true Arctic plants, such as *Betula nana*, *Dryas octopetala*, *Salix reticulata*, *S. polaris*, and *S. herbacea*, and with shell-marls, on which were formed various peat-beds in succession. On the margins of these, trees of successive forests grew and fell in. First *Populus tremula*, and then Pine-forests, with the *Stone* weapons of the aborigines; and succeeding Oaks, with *Bronze* weapons of another race of men; and Beeches at last, with the *Iron* implements of Historic Man; these are clearly seen there, one after another." ("Sc. for All," *l.c.*, Steenstrup's Memoirs "Transact. Acad. Sci., Copenhagen," Vol. ix., 1842, &c., &c.; and especially his paper, "Sur les Köjkken-möddings' de l'âge de la pierre et sur la faune et la flore préhistoriques de Danmark," Extr. des Bulletins du Congrès International d' Archéologie préhistorique à Copenhague en 1869. 8vo., Copenhagen, 1872. See also "Lecture on the Antiquity of Man," by T. Rupert Jones, 8vo., Van Voorst, 1877, pp. 10-18.)

The enormous stretch of country covered with the Black-earth (Tchernay-zem), in South Russia, was referred to as the result of long-continued decay of plants over a large area where the drainage has not allowed the permanent formation of watery peat.

II. (6). The *Deltas* of river-valleys, or partially filled gorges mentioned above, where they meet the sea-level, and the suspended mud falls in the slackened current, comprise many kinds of peat-forming water-areas. There are isolated *bends* and deserted *reaches* of devious watercourses, lakes in sunken hollows of the soil, "slakes" or stagnant side-waters of the river, and imprisoned back-waters and lagoons of the sea. These become choked with water-plants and silt, either continuously or in successive stages. Various kinds of morasses are thus formed, which here and there contain seams of sand, shells, and weeds left by the sea after stormy irruptions, or after quiet temporary possession.

Mr. A. G. Cameron has described in the "Geol. Mag.," Ser. 2, Vol. v., p. 351, a small maritime peat-deposit at West Hartlepool, consisting of eight feet of peat, with 32 inches of under-clay. The alluvial flats in Sussex are noticed in Dixon's "Geology of Sussex," new edition, 1878, Chapter viii.; and Mr. E. H. Butler's explana-

tion of the history of those near Hastings is alluded to at page 149.

The famous swamp in the Delta of the Nile, anciently known as "Lacus Serbonis," and subject to inundations from the Mediterranean, although not a true Peat-bog, comes under this division of deltaic morasses. Treacherous sands and mud, overgrown with reeds and reed-like plants (the "Sea of Reeds," in Hebrew, "Contemporary Review," Vol. xxxiv., p. 757), constitute—

> "That Serbonian bog,
> Betwixt Damiata and Mount Casius old,
> Where armies whole have sunk."—*Milton.*

II. (7.) Where the present sea-line intercepts the broadest valley-flats or alluvial plains, we have *Maritime Marshes*, often of vast extent, especially across the embouchure of several neighbouring rivers, formerly affluents of one great river, then running in its gorge-track, but now obliterated by the encroachment of a narrow sea, or lost in it by the subsidence of the country.

In Lyell's "Second Visit to the United States" (2 vols., 1850), it is stated, at page 30, Vol. i., that partial subsidence of the land on the eastern coast within recent periods has formed swamps, with stumps of *Cupressus thyoides* still standing. Such cedar-swamps on the east side of Delaware Bay contain large prostrate trees to an unknown depth. In one case a tree with upwards of a thousand annual rings was found to lie over one of five hundred years' growth. See also Dr. Dawson's "Notices of the Modern Submerged Forests of Nova Scotia, "Quart. Journ. Geol. Soc.," Vol. xi., p. 119, &c.; and "Acadian Geology," 2nd Edit., p. 28, &c.

The Fen-lands of England were referred to in illustration, especially the "Levels,"* in Cambridgeshire and neighbouring counties; also the low grounds of the ancient gulf of Poitou, the filled-up estuary of Flanders, the largest part of Holland, and of German and Danish Friesland.

"The Tûndras of Northern Russia and Siberia, now permanently frozen below, and covered with snow nine or ten months of

* These are the—1, "North Level;" 2, "Middle Level;" 3, "South Level;" and 4, "Bedford Level." The sluice at St. Germains, draining the "Middle Level," broke in 1862, and inundated more than a thousand acres of the "Marshland," between that and the sea. The "Marshland" was enclosed before the "Middle Level," which was drained between forty and fifty years ago.

the year, are also characteristic maritime swamps, involving the broad, low deltas of the great rivers that enter the Arctic Ocean. These extensive and melancholy flats are varied with lakes of salt and fresh water, and are green with coarse grass, rushes, and sedge, and with plots of bog-moss, during their short summer of nine or ten weeks. Whatever else the unsearchable Tûndras may contain, the ancient Mammoth and Rhinoceros, still preserved entire in their frozen muds, tell of long past changes in Northern Asia. But in Europe and the British Isles, where nation has pressed upon nation in forced emigrations, the Peat-bogs teem at places with recognisable relics of the past.

"§ IV. Weapons and tools of stone, bronze, and iron, besides the bones, garments, and ornaments of man, also his canoes, his crannoges or artificial island-forts, and his pile-structures once supporting huts, and even villages, in marshes and lakes, with the associated rude or finished implements and other belongings of his domestic life, are all found in Peat-bogs, and can be referred to different peoples. Thus, when fully studied, a Peat-bog often enables us to obtain an insight, not only into many geological changes in far back time, but also into the history of races of men who have left no written records, no buildings of brick or stone, to bear witness of their life, and nevertheless played an active part in founding the civilisation in the midst of which we now live" ("Science for All," No. 23, pages 347, 348).

APPENDIX I.

A Catalogue of the more important British Plants that, living in wet and marshy places, in rivers and lakes, and on bogs, supply vegetable material for the formation of Peat.

1. Cryptogams.

Of the many *Confervoid Algals* that abound in fresh water, we may take as types—*Lemania*, *Batrachospermum* (Knotweed), *Chætophora*, *Conferva* (Crowsilk), *Zygnema*, *Bulbochæte* (Bristleweed), *Vaucheria*. *Oscillatoria* (Quickthread), and *Scytonema* (Leatherthread), *Nostoc*, *Desmidium*, *Diatoma*, and *Volvox*. See "Micographic Dictionary," Van Voorst, 1875.

In the remainder of this List of Aquatic Plants the names and

order given in S. F. Gray's "Natural Arrangement of British Plants," 8vo., 2 vols., 1821 (a very useful, though old-fashioned work), is mainly followed.

The affixed signs mean—
- * growing in the water.
- † growing on bogs.
- ‡ growing in wet situations.
- § growing in salt marshes.

Filices.	‡ Osmunda regalis	... Royal Flowerfern; Water-fern.
„	‡ Blechnum boreale	... Northern Spicant; Hard Fern.
Lycopodiaceæ.	† Lycopodium inundatum	... Bog Wolfsclaw; Creeping Club-moss.
„	‡ „ abietiforme	... Firlike Club-moss (*Mountains*).
„	* Isoetes lacustris	... Lake Quillwort (*Alpine lakes*).
Marsiliaceæ.	* Pilularia globulifera	... Peppergrass; Pillwort.
Equisetaceæ.	‡ Equisetum fluviatile	... Great or River Horsetail.
„	‡ „ hyemale	... WinterHorsetail; Dutch Rush.
„	‡ „ limosum	... Mud Horsetail.
„	‡ „ variegatum	... Variegated Horsetail.
„	† „ palustre	... Marsh Horsetail.
Charadeæ.	* Chara vulgaris	... Common Stonewort.
„	* „ hispida	... Hispid „
„	* „ crinita	... Hairy „
„	* Nitella flexilis	... Flexible „
„	* „ stellata	... Starred „
Musci.	(Some *Hepaticæ*, especially *Jungermanniæ.*)	
„	† Sphagnum (Bogmoss) obtusifolium, squarrosum, acutifolium, cuspidatum.	
„	‡† Splachnum (Glandmoss) tenue (*Mountains*), vasculosum (*Alpine bogs*).	
„	‡† Dricanum (Forkmoss), adiantoides, cerviculatum, flexuosum, virens and strumiferum (*Mountain bogs*), squarrosum, crispum.	
„	* Trichostomum aciculare	... Needle-like Hairymouth.
„	* Orthotrichum rivulare	... River Bristlemoss.
„	* Fontinalis antipyretica	... Fireproof Springmoss; Water-moss.
„	* „ squamosa	... Scaly „ (*Alpine streams*).
„	† Batramia fontana	... Grey or Spring Marshmoss.
„	† „ arcuata	... Bowed „ (*Mountain bogs*).
„	† Hypnum stramineum	... Straw Feathermoss.
„	‡ „ stellatum	... Starred „
„	† „ cuspidatum	... Bladed „
„	† „ nitens	... Shining „
„	* „ fluitans	... Floating „

Musci.	‡	Hypnum palustre	... Marsh Feathermoss.
,,	†	,, filicinum	... Fern ,,
,,	*	,, ruscifolium	... Butcher's-broom-leaved Feathermoss.
,,	†	,, aduncum	... Crooked Feathermoss.
,,	†	,, cordifolium	... Heart-leaved ,,
,,	†	,, scorpioides	... Scorpion ,,
,,	‡	,, riparium	... Bankside ,,
,,	*	,, molle	... Soft ,, (*Alpine rivulets*).
,,	†	Bryum palustre	... Marsh Threadmoss.
,,	†	,, trichodes	... Hair-leaved Threadmoss (*Mountain bogs*).
,,	†	,, dealbatum	... Whitened Threadmoss (*Mountain bogs*).
,,	‡	,, triquetum	... Three-edged Threadmoss.

2. PHANEROGAMS.

Fluviatiles.	*	Zaniohellia palustris	... Marsh Pondweed.
,,	*	,, dentata	... Toothed ,,
,,	§	Ruppia maritima	... Sea Tasselgrass.
,,	*	Potamogeton natans	... Swimming Riverweed.
,,	*	,, heterophyllum	... Odd-leaved ,,
,,	*	,, fluitans	... Floating ,,
,,	*	,, lucens	... Shining ,,
,,	*	,, crispum	... Crisp ,,
,,	*	,, lanceolatum	... Spear-shaped Riverweed (*Mountain lakes*).
,,	*	,, perfoliatum	... Thorough-leaved Riverweed.
,,	*	,, densum	... Thick ,,
,,	*	,, compressum	... Flat ,,
,,	*	,, pectinatum	... Fennel-leaf ,,
,,	*	,, gramineum	... Grasslike ,,
,,	*	,, pusillum	... Small ,,
,,	§	,, marinum	... Maritime ,,
,,	§	Zostera marina	... Sea Grasswrack.
Lemnadeæ	*	Lemna trisulca	... Three-lobed Duckmeat; Duckweed.
,,	*	,, minor	... Smaller Duckmeat; Duckweed.
,,	*	,, polyrhiza	... Many-rooted ,,
,,	*	,, gibba	... Bunched ,,
Typhaceæ.	‡	Sparganium ramosum	... Branched Burreed.
,,	‡	,, simplex	... Unbranched Burreed.
,,	‡	Platanaria natans	... Floating Ribandweed.
,,	‡	Typha latifolia	... Broadleaved Reedmace.
,,	‡	,, angustifolia	... Narrowleaved ,,

Cyperaceæ.	‡†§	Carex (Grassrush) dioica, Davalliana, pulicaris, teretiuscula, paniculata, vulpina, intermedia, divisa (*maritime*), ovalis, elongata, stellata, curta, axillaris, cæspitosa, stricta, acuta.	
„	‡†§	Trasus (Sedge) pauciflorus (*Alpine bogs*), hirtus, filiformis (*bogs*), vesicarius and ampullaceus (*bogs*), flavus and fulvus (*bogs*), distans (*maritime bogs*), riparius, paludosus, ustulosus (*mountains*), lævigatus, limosus (*bogs*).	
„	†	Cyperus longus	... Sweet Cyperus; English Galingale.
„	§	Cladium Germanicum	... Picklerush; Prickly Bogrush.
„	†	Chætospora compressa	... Flat Marshrush.
„	†	„ rufa	... Reddish „
„	†	Rhynchospora alba	... White Beakrush.
„	†	„ fusca	... Brown „
„	†	Schœnus nigricans	... Black Bogrush.
„	†	„ ferrugineus	... Thorny „ (*Mountain bogs*).
„	‡	Scirpus cæspitosus	... Tufted Rush (*Turfy heaths*).
„	†	„ pauciflorus	... Few-flowered „ (*Hill bogs*).
„	†	„ multicaulis	... Many-stemmed „
„	‡	„ lacustris	.. Lake Bullrush.
„	‡	„ medius	... Middling Bullrush.
„	‡	„ carinatus	... Keeled „
„	§	„ triqueter	... Three-sided „
„	§	„ pungens	... Prickly „
„	§	„ maritimus	... Seaside „
„	†	Elæocharis acicularis	... Needly Clubrush (*Wet heaths*).
„	‡	„ palustris	... Marsh „
„	†	Isolepis fluitans	... Floating Smoothrush.
„	‡	„ paniculata	... Panicled „
„	†	Trichophorum alpinum	... Alpine Harestail.
„	‡	Eriophorum capitatum	... Headed Cottongrass (*Wet heaths*).
„	†	„ vaginatum	... Sheathed Cottongrass.
„	†	„ angustifolium	... Narrow-leaved Cottongrass.
„	†	„ latifolium	... Broad-leafed „
„	†	„ gracile	... Slender „
Gramineæ.	‡	Nardus stricta	... Stiff Matgrass (*Wet heaths*).
„	‡	Poa aquatica	... Water Meadowgrass.
„	§	„ maritima	... Seaside „
„	§	„ glauca	... Glaucous „
„	‡	Glyceria fluitans	... Floating Maundgrass; Flotegrass.
„	‡	Arundo vallatoria (phragmitis)	... Bankside Reed.
„	‡	Catabrosia aquatica	... Water Sweetgrass.
„	†	Phalaris arundinacea	... Reedy Phalaris.

Gramineæ.	§ Alopecurus bulbosus	... Bulbous Foxtail.
„	‡ „ geniculatus	... Kneed „
„	‡ „ fulvus	... Reddish „
„	§ Spartina stricta	... Stiff Seagrass.
„	‡ Vilfa alba	... White Bent; Marsh Bentgrass.
„	§ „ maritima	... Seaside Bent.
„	‡ Apera? palustris	... Marsh Silkgrass.
„	‡ Calamagrostis neglecta	... Neglected Reedgrass.
„	§ Polypogon littorale	... Shore Beards.
Restiaceæ.	‡ Eriocaulon septangulare	... Sevenangled Pipewort (*Lakes, Hebrides*).
Junceæ.	‡ Acorus undulatus (calamus)	Wavy Sweetflag.
„	§ Juncus acutus	... Sharp Junk or Rush.
„	§ „ maritimus	... Seaside „
„	§ „ cænosus	... Mud „
„	‡ „ bufonius	... Toad „
„	† „ macer	... Slender „ (*Alpine bogs*).
„	† „ trifidus	... Three-cut Junk or Rush (*Alpine bogs*).
„	† „ supinus	... Downlying Junk or Rush.
„	‡ „ uliginosus	... Woolly „ (*Wet heaths*).
„	† „ fluitans	... Floating „
„	† „ triglumis	... Three-chaffed „
„	‡ „ subverticillatus	... Whorled „
„	‡ „ acutiflorus	... Sharp-flowered „
„	† „ lampocarpus	... Shiny-fruit „
„	‡ „ obtusiflorus	... Blunt-flowered „
„	† Luzula congesta	... Flaxen Rush; Crowded Luzula.
„	† „ multiflora	... Many-flowered Luzula.
„	† Abama ossifragum	... Bonebreaking or Lancashire Bastard Asphodel.
Colchicaceæ.	† Tofieldia palustris	... Marsh Tofield; Scottish Asphodel (*Mountain bogs*).
Irideæ.	‡ Iris palustris	... Marsh Fleur-de-luce: Yellow flag; Seggs.
„	‡ „ variabilis	... Changeable „
Orchideæ.	‡ Orchis latifolia	... Broad-leaved Orchis; Marsh Satyrion, &c.
„	‡ Listera cordata	... Heart-leaved Twayblade.
„	‡ Epipactis palustris	... Marshy Helleborine.
„	† Malaxis paludosa	... Marsh Twayblade.
Alismaceæ.	‡ Sagittaria aquatica	... Water Arrowhead.
„	‡ Alisma major	... Greater Water-plantain.
„	‡ „ natans	... Floating „ (*Alpine lakes*).

Alismaceæ.	‡	Alisma ranunculoides	... Ranunculus-like Water-plantain.
„	†	Damasonium Dalechampii	... Starhead.
Butomaceæ.	‡	Butomus umbellatus	... Umbelled Gladiole.
Juncagineæ.	†	Scheuchzeria palustris	... Marsh Scheuchzer.
„	‡	Triglochin palustre	... Spiked Watergrass; Marsh Arrowgrass.
„	§	„ maritimum	... Saltmarsh Watergrass; Sea Arrowgrass.
Hydrocharideæ.	*	Hydrocharis asarifolia (morsus-ranæ)	... Asarum-leaved Frogbit.
„	§	Stratiotes aloides	... Aloe-like Watersoldier.
Gentianeæ.	†	Menyanthes palustris	... Marsh Buckbean.
Boragineæ.	‡	Myosotis palustris	... Marsh Mouse-ear; Forget-me-not.
Droseraceæ.	†	Drosera rotundifolia	... Round-leaved Sundew.
„	†	„ longifolia	... Long-leaved „
„	†	„ anglica	... English „
Nymphæaceæ.	*	Nuphar luteum	... Yellow Watercan or Water-lily.
„	*	„ minimum	... Smallest „
„	*	Nymphæa alba	... White Waterlily.
Ranunculaceæ.	‡	Caltha palustris	... Marsh Marygold.
„	*	Ranunculus sceleratus	.. Wicked Crowfoot.
„	‡	„ reptans	... Creeping Crowfoot (*Alpine lakes*).
„	†	„ flammeus	... Flame Crowfoot; Banewort.
„	‡	„ longifolius (lingua)	... Long-leaved Crowfoot; Great Spearwort.
„	*	Batrachium hederaceum	... Ivy-like Water-crowfoot.
„	*	„ tripartitum	... Three-parted „
„	*	„ obtusifolium	... Blunt-petaled „
„	*	„ heterophyllum	... Odd-leaved „
„	*	„ pantothrix	... Trimmed „
„	*	„ cæspitosum	... Tufted „
„	*	„ fluviatile	... River „

APPENDIX II.

Besides the books and memoirs mentioned in the foregoing paper, the following list of published works treating of Peat may be useful to some who wish to study the subject. They are mentioned not as forming by any means an exhaustive catalogue, but as the titles of, and notes on such as occurred to me whilst looking up lecture-notes on the subject.

1810. Essays on the Natural History and Origin of Peat Moss: the peculiar qualities of that substance; the means of improving it as a soil; the methods of converting it into a manure; and the other economical purposes to which it may be made subservient. By the Rev. R. Rennie, D.D., &c. 8vo. Edinburgh, 1810.

Essay I. treats of ligneous plants: the former abundance of forests, their destruction, and origin of Peat-mosses therefrom. II. On aquatic plants: the part they play in forming Peat-mosses in lakes, &c. III. On the changes and combinations by which vegetable matter is converted into Peat-moss. IV. On the simple and compound substances that may be expected, and are really found in Peat-moss. V. On the alliance between Peat, Surturbrandt, Coal, and Jet. VI. On the alliance between Peat and other Bituminous Substances. VII. The distinguishing qualities of Peat-moss. VIII. The sterility of Peat-moss in its natural state, and causes of it. IX. The different kinds and classification of Peat-moss.

The outlines of four "Practical Essays on Peat-moss as a Soil, Manure, Fuel," &c., are appended to the volume, but these do not appear to have been published. Numerous observers and writers are referred to and quoted in Rennie's Essays, which are full of local and general information about Peat, which was then better known as "Moss" (from the Celtic *Mos*; see Essay III., p. 240), whilst the word "Peat" referred only to the piece dug out for fuel. (Dr. James Geikie has kindly given me notes on the contents of Nos. I. and II., which are wanting in some published volumes of the "Essays.")

[?] In his "Practical Treatise on Peat," Dr. Anderson tried to show that Peat is a plant *sui generis*! It is a useless, preposterous, and absurd book, and looks as if meant for a kind of heavy joke. (J. Geikie, in a letter).

1811. A Treatise on the Origin, Qualities, and Cultivation of Moss-earth, with directions for converting it into Manure. By William Airton, Writer (lawyer), Strathaven, Lanarkshire. 8vo. Ayr., 1811.

He concludes that Moss-earth has been produced by plants in a climate of low temperature with excess of moisture; and he classifies the different sorts found in Britain as—1. Hill-moss; on hill-tops and hilly acclivities, where Heather and the Mosses—Hypnum, Bryum, Polytrichum, and Sphagnum form a kind of thin half-peat. 2. Bent-moss, much thicker, on the sides and skirts of hills,

and composed largely of the coarse grasses (Bent, &c.), mixed with the usual bogforming mosses. 3. Flow-moss, or quaking-bog, composed chiefly of Sphagnum, filling old lakes, and covering overthrown forests. (From Dr. James Geikie).

1821. J. Templeton, of Belfast, "On the Formation of Peat-bogs," in a letter to Dr. Berger, "Transactions Geological Society," Vol. v., pp. 608, &c. 4to., London, 1821.

This was written from observations made whilst doubts still existed with some geologists and mineralogists as to the origin and formation of Peat. Mr. Templeton states—"No bog is ever formed without an abundant stock of moisture. . . . . The greatest mass of bog almost uniformly derives its origin from impediments intercepting the flow of water from a valley. A lake is thus formed, in whose waters is only nourished, if in mountain regions, the *Lobelia Dortmanni*, and sometimes the *Sparganium natans*, with a few straggling stunted plants of *Scirpus lacustris*. If in the lowlands a greater variety appear—we may observe the curious *Conferva echinulata*, floating like powdered verdigris; immersed at even greater depths grow Sponges, the *Charæ*, the *Ceratophyllæ*, with numerous *Confervæ*; and around the shores, gradually approaching the centre as their annual decay lessens the depth of water, we find various species of *Potamogeton*, the *Nymphæa alba*, *N. lutea*, the *Lobelia Dortmanni* (if the shore is composed of sand or gravel)," and upwards of thirty enumerated water-loving plants. To these plants succeed those which require to have themselves altogether uncovered with the water, or their roots fixed in a watery or soft mud, as the fourteen Mosses then enumerated. Among these Mosses grow other plants that like moisture, and "when the bog rises higher and is somewhat drier" another group of plants flourish until a firmer and fibrous kind of plant is formed. Sound conclusions are drawn by the author.

1826. Natural and Agricultural History of Peat-moss or Turf-bog, to which are annexed corroborative writings, correspondence, and observations on the qualities of Peat or Fen-earth, as a soil and manure, and on the methods used in Scotland for converting Moss-soils into arable and pasture grounds, plantation of trees, &c. By Andrew Steele, Esq., &c. Edinburgh, 8vo., 1826.

Very many references to other writers and practical observers are herein made; the special flora of Peat-mosses is mentioned, with the common names of the plants (p. 299, &c.), and at p. 399

&c., are Prof. Robert Jameson's "Observations on Peat," from his "Mineralogical Travels through the Hebrides," &c.

1826. Gordon. Trans. Geol. Soc., ser. 2, Vol. ii., p. 140.

A notice of three successive forests of Fir in a Peat-moss.

1841. The History and Description of Fossil Fuel, the Collieries, and the Coal-trade of Great Britain. [By — Holland]. 2nd edit., 8vo., London, 1841. Chapter III., Peat, p. 40., &c.

1841. Practical Geology and Mineralogy, &c. By Joshua Trimmer. 8vo., London, 1841, p. 413, &c. Turf-moors and Peat-bogs.

Chief authors mentioned: Peat between vegetable matter and lignite: growth of *Sphagnum:* Peat over ruined forests: Antiquities in Hatfield Moss: human bodies, &c., in Peat.

1847. Lesquereux. "On the Formation of Peat in the North of Europe." Bulletin Soc. Sci. Nat. Neufchatel, 1847, vol. i., p. 472; and Quart. Journ. Geol. Soc., Vol. iv., Miscell., p. 29.

The formation of (1) *Immersed* or *Submerged Peat,* (2) of *Emerged* or *Superficial Peat,* (3) *Superficial Peat* sinking to form *Bottom Peat,* is noticed; and some different Peat-bogs are compared. The passage from peat to lignite and coal, and the great quantity of successive forests in some Peat-bogs is noticed.

1853 (?). D. T. Ansted's "Physical Geography and Geology." (Orr's Circle of Sciences.) 8vo., London, 1853 (?), p. 219, &c.

1855. In Rowland and Richardson's "Chemical Technology," 2nd edition, 2 vols., 8vo., 1855, the changes of wood into peat, &c., or the process of transformation from living and dead vegetable fibre to compact lignite, jet, and coal—or carbonization by the process of hystolysis (retrograde decay), are treated of in some detail.

1856. Studi sopra alcuni Torbe Veronesi. Rapporto della Commissione incaricata della ricerca della torba nella Provincia di Verona. 8vo., Verona, 1856, pp. 37.

1857. Der Torf, seine Enstehung, Natur und Benutzung, nebst Aufforderuing durch Berarbeitung desselben einen zu weitem Transport und zu jeder Art von Feuerung zeeigneten Brennstoff darzustellen. Von H. Schinz-Gessner. Zurich, 1857, 8vo., pp. 43.

1860. In the Article "Turf," in the "Aide-mémoire to the Military Sciences," Vol. ii., 1860, pp. 175 *et seq.*, J. E. Portlock (*afterwards* General) enumerated the Alt-Warmbrücher Moor; Franzensbad; Ireland; Banks of North Sea; Gördauer Lake;

East Sea; San Paulo, Brazils; Langensalza; Wittgendorf. He also refers to marine remains in alluvium, and to antiquities in the alluvium of Sweden; a Roman bridge in peat, and the buried hut in Galway.

1860. Pokorny. On Peat and Brown-coal. Proceed. Imp. Geol. Instit., Vienna, 1860; Transact. Vienna Zoolog.-Botan. Soc., 1860; and Quart Journ. Geol. Soc., Vol. xvii., Miscel., p. 6.

Prof. Pokorny, in publishing the results of his examination of the principal Peat-bogs of the Austrian Empire, groups his materials under these headings:—1 Vegetables in progress towards conversion into Peat. 2. Peat of the plains and of the mountain-moors. 3. Resinous substances, such as the dopplerite of the Aussee in Styria, and analogous substances from Switzerland and Berchtesgaden, described by Deicke and Gümbel. 4. Half-peat, with much inorganic matter, but combustible.

1862. F. Senft. Die Humus-, Marsch-, Torf- und Limonit-Bildungen alz Erzeugungsmittel neuer Erdrindlagen [für Geognosten, Bergleute, Forst- und Landwirthe]. Von Dr. Ferdinand Senft, &c. 8vo., Leipzig, 1862.

In this useful work the following grouping is adopted (p. 126, &c.):—

1. Moos-torf, consisting of *Sphagnum* chiefly.
2. Gras- oder Wiesen-torf (Darg). *Cyperaceæ*, &c.
3. Haide- or Hochmoor-torf (Hagetorf). *Erica*, *Calluna*, &c.
4. Blätter- or Wald-torf. Yellowish, flaky; made of needles of Pines and leaves of Alder, Birch, Willow, Aspen, and sometimes Elm, Maple, &c.
5. Algen- (oder Meeres-)torf. Of *Algæ*, as at Flensburg, Oseland, Trelleberg, &c.

1862. In the Official Catalogue of the Mining and Metallurgical Products, Zollverein Department of the International Exhibition, 1862, MM. von Dechen and Wedding gave some valuable information on the German Peat at pp. 26, 27.

1864. T. Sterry Hunt: "Peat and its Uses," 8vo., in the "Canadian Naturalist and Geologist," 1864. See also the Reports of the Geological Survey of Canada.

1866. James Geikie, "On the Buried Forests and Peat-mosses of Scotland, and the Changes of Climate they indicate." Transactions R. Soc. Edinb., Vol. xxiv., 1866, p. 363, &c.

Full of both detailed and generalized information, and rich with

references to other writers and observers. Two kinds of Peat-bog are particularly distinguished—1. The ordinary Peat-moss, due to the upgrowth of *Sphagnum* and its associates from the soil, and often including timber. 2. The Flow-moss, formed of floating intermatted vegetation over a basin of water, which receives, and may be filled by, a thick deposit of rotting plants from the bottom of the raft-like Moss. The former great extent of the Mosses, their antiquity, and the changes of climate connected with their history, are also treated of in full.

1866 (?). Peat and its Uses as Fertilizer and Fuel. By Samuel W. Johnson, Professor at Yale College. Illustrated, 8vo., New York, 1866 (?).

At page 168, &c., the origin and varieties of Peat are treated of; also the floating islands of turfy material in Germany, &c. The constituent Plants mentioned at page 12 are—*Sagittaria, Pantederia, Lemna, Potamogeton, Polygonum, Nymphæa*, and *Nuphar*.

1867. Prof. Archibald Geikie, has favoured me with the following copy of Title-pages :—

1. "Facts about Peat, as an article of Fuel, with remarks upon its Origin and Composition, the Localities in which it is found, the Methods of Preparation and Manufacture, and the various uses to which it is applicable; together with many other matters of practical and scientific interest. To which is added a Chapter on the Utilization of Coal Dust with Peat, for the production of an excellent fuel at moderate cost, specially adapted for steam service. By T. H. Leavitt. 3rd edition, revised and enlarged. Boston: Lee and Shepard, 1867."

2. "Leavitt's Peat Journal: a Newspaper devoted especially to the dissemination of information relating to Peat, its preparation and use as an article of Fuel, and generally to all that pertains to the economical production and use of fuel of all kinds. Issued monthly, by Leavitt and Hunnewell, 49, Congress Street, Boston. Price fifty cents. per annum. For sale by all newsmen."

1868. "The Observations on the Formation of Peat, in Lyell's "Principles," 10th ed., 1868, pages 496, &c., deal with the growth of Peat and preservation of Vegetable and Animal Remains therein; the analysis of Peat; Peat abundant in cold and humid climates (North and South); extent of surface covered with Peat; supposed recent origin of some Peat-mosses; source

of Bog-iron-ore; Preservation of animal substances in Peat; cause of the antiseptic property of Peat; the miring of Quadrupeds; Solway Moss; bursting of Peat-mosses; bones of Herbivorous Quadrupeds in Peat, and the Great Dismal Swamp, p. 505.

1868. J. W. Dawson, in his "Acadian Geology," 2nd ed., p. 33, 1868, treats of Freshwater Alluvia, "River intervales," and deposits forming in the beds of lakes; Intervales on the banks of streams; Soil on gravel; Lake-beds; Diatomaceous earths; Bogs and peaty swamps, p. 35, numerous in Nova Scotia in the rocky districts of the Atlantic coast.

1870. Traité complet de la Tourbe formation, gisément et composition des diverses espèces, extraction, desiccation naturelle et artificielles, travaux mécaniques, carbonisation, &c. Culture des tourbières, roselières, rizières et engrais. Législation des marais et des Tourbières. Benzine, acide phénique, etc. Emploi de la tourbe en metallurgie. Par Ernest Bosc. Paris, 8vo., 1870, pp. 242. 20 figs. in the text.

1871. On the economical production of Peat and Peat-charcoal, with incidental reference to the processes pursued at the Redmoss Works (Peat-engineering and Sewage-filtration Company Limited), Horwich, near Bolton, Lancashire. Liverpool, 8vo., 1871, pp., 24.

1874. "Die Turfmoore Oesterreichs und der angrenzenden Lander, ihre Wichtickeit für Staats-Œkonomie und Industrie. Nebst einem Anhange: Ueber die Darstellung der Anilinfarben." Von Georg Thenius. Wien, 1874, 8vo., pp. 202.

In this work we have a plan and several sections of a part of the great Bürhmoos.

1876. "The Geology of England and Wales." By H. B. Woodward, F.G.S. 8vo., London, 1876. Alluvial deposits, p. 326, &c. Peat, p. 357, &c. Mr. Alfred Gillett's list of water-plants, p. 358-9.

1876. Oswald Heer. "Primeval World of Switzerland." English Translation by W. S. Dallas, edited by J. Heywood. 2 vols., 8vo., London, 1876.

In Vol. i., p. 24, &c., the following points are especially referred to:—Origin and formation of Peat; stagnant water; bottom impervious; Algals and other plants; Sphagnum, &c. Peat of rivers and lakes; Peat of Gonten and Oberburgen; Pfäffikon, Wetzikon, Robenhausen, Katzensee, &c. Drowned forests; general statement; p. 29, formation and action of acids; changes in Peat; paper-coals; Peat of Virginia and Carolina (Lesquereux).

1877. Report of the Geological Survey of Wisconsin. 1877. Peat deposits, p. 29, p. 241, &c. Marsh Vegetation, p. 181.

1877. The Danish Peat (after Steenstrup), in T. Rupert Jones's "Antiquity of Man." 8vo., London, 1877, pages 10 to 17.

On hills.	Lyngmose (Heath), Svampmose (Spongy), Hœrmose (Flax-like, from the superficial dead Mosses): Denmark. Heidenmoor (Heath), Hockmoor (High); North Germany. Moor-turf, Hill-moss; Britain.
In valleys.	Kjermose (Marsh), Engmose (Meadow); Denmark. Wiesenmoor (Meadow); Germany. Peat-moor, Peat-moss, Bent-moss, Marsh, &c.; Britain.
In forests.	Skovmose; Denmark. Woldmoor; Germany. Forest-bog; Britain.

1877. S. B. J. Skertchley, Geology of the Fenlands; Memoirs of the Geological Survey of Great Britain, &c., 1877.

1878. S. H. Miller and S. B. J. Skertchley. The Fenlands Past and Present. 8vo., 1878.

1. In the Peat.—The Animal remains (p. 340):—Man, Celtic shorthorned Ox (*Bos longifrons*), a variety (*B. euryceros*), *Bos* (*Urus*) *primigenius*, Wolf, Fox, Goat, Beaver, Roe, Stag, Irish Deer (*Megaceros hibernicus*), Reindeer, Otter, Marten, Brown Bear, Wild Boar, Horse; Bittern, Wild Swan (*Cygnus masicus*), Tame Swan (*C. olor*), Coot, Pelican, Crested Grebe, Teal; Tortoise; Pike; Insects; Molluscs—*Bithinia, Helix, Limnææ, Planorbes, Physa, Cyclas, Valvata, Pisidium.*

The Plants found in the Peat (p. 341):—

Betula nana.	Hypnum fluitans.
Fagus sylvatica.	——— filicinum.
Fraxinus.	Juncus aquaticus.
Salix capra.	Lastrea.
—— repens.	Sphagnum.
Quercus robur.	Confervæ.
Pinus sylvestris.	Polyporus fomentarius.
Taxus baccatus.	———— squamosus.
Ulmus.	Sphæria (?) concentrica.
Hydrodictyon utriculum.	

2. In the Silt (marine) below the Peat:—

Walrus.	Cockles.
Grampus.	Mussels.

1878. T. Mellarde Reade, in the Quart. Journ. Geol. Soc., Vol. xxxiv., p. 447, on the submarine forest at Altmouth; and at p. 808, on Glazebrook Moss, Lancashire.

1878. Transactions of the Newbury District Field Club, Vol. ii., 1878; Dr. S. Palmer on the Antiquities found in the Peat of Newbury, p. 123, &c., and Appendix by T. Rupert Jones; reprints of Dr. Collet's and Dean Buckland's descriptions of the Peat-formation in the Valley of the Kennet, and various notes on the Newbury Peat; p. 135, p. 138, p. 141, &c.

1879. A. Bailey: Overflow of a Peat-bog* in the Falkland Islands. Quart. Journ. Geol, Soc., Vol. xxxv., p. 96.

1879. I combustibili minerali d' Italia. W. Jervis. 8vo., 89 pp. Turin, 1879; The Peat of Italy, in the Alpine Region, Apennine Region, and Islands, pp. 64-89.

EXCURSION TO TUNBRIDGE WELLS AND CROWBOROUGH BEACON.

MONDAY, JULY 12TH, 1879.

FIFTH OF THE WEALD SERIES.

Director.—J. LOGAN LOBLEY, Esq., F.G.S.

(*Report by* WILLIAM FAWCETT, ESQ., B.SC.)

On alighting from the train at Tunbridge Wells, the Members proceeded by way of the Common, where the Director explained the route to be followed, then to the Parade to taste the waters, to the Pump Room, and, after crossing the boundary of Kent and Sussex, to Broadwater Down. Here, with almost the whole of Tunbridge Wells in view, Mr. Lobley pointed out that the town was built just at the junction of two valleys. The higher ground is Tunbridge Wells Sand, with outlying patches on Rusthall

* In the Museum of Practical Geology, Jermyn-street, is a good model of a burst Bog in Lanarkshire.

Common and elsewhere of Weald Clay, while in the valleys Wadhurst Clay occurs.

The Marquis of Abergavenny had with great courtesy invited Mr. Lobley to conduct the Members through Eridge Park to the Castle, and had very kindly instructed Mr. Rush, of Eridge, to accompany the party, and point out everything of interest in the magnificent domain, one of the oldest enclosed parks in the kingdom. On arriving at Eridge Castle the Members were most heartily received and hospitably entertained in the Banqueting Hall. Two cannon balls were exhibited, the first made in England. Prof. Morris referred their manufacture to the year 1543 A.D., when the first cannon of English make was produced at the then famous Sussex furnaces. A hundred years later, during the Civil War, many of the furnaces were destroyed, and from that time the gradual extinction of the old forest of the Weald, and the consequent loss of fuel, led to the decline and ultimate cessation in the beginning of the present century of the Wealden iron furnaces. But the loss has only been a local and a temporary one. Some three or four of the ironmasters of Sussex, finding fuel growing scarce in their own country, established themselves in Wales, and were the first promoters of the iron-trade of Merthyr Tydvil and Aberdare—a trade which has grown to such vast dimensions in our own day, and has contributed in no small degree to the wealth and influence of the British Empire. Were coal found in Sussex the iron-furnaces might again be lighted, but the increase in prosperity would in the eyes of many be more than counterbalanced by the change from smiling valleys to a desolate "black country." Before leaving the Castle, Mr. Lobley expressed the thanks of the party to the noble Marquess for his courtesy and hospitality.

From the lawn in front of the Castle there is a good view of the well-wooded Wadhurst Clay valley, which forms a large portion of the grand old park. The Eridge Rocks in another portion of the park were examined, and compared in many points with the Toad and High Rocks. The position of the Eridge Rocks, inasmuch as they are in a sheltered position, seems to militate against a theory of Ramsay's, who has endeavoured to account for the peculiar undercutting by pointing out the enormous force with which the wind files away at the base of the rocks by means of the sand—a natural emery powder. A discussion arose with regard to the

origin of the hemispherical markings; Mr. Lobley suggested that they were structural, and compared them with the "box-stones" of the Sevenoaks quarries; Professor Morris pointed out that they followed the lines of false bedding. This false bedding proves the existence of varying currents in the great river which laid down the Tunbridge Wells Sand as part of its delta. Attention was called to a very "clean" cleft; it is remarkable that these "clefts" run parallel in a direction nearly N.W. and S.E.

After thanking Mr. Rush for his able guidance, the party left Eridge and followed the road to Uckfield. After gradually ascending, they soon found themselves on ground commanding most extensive views as well over the cultivated region as over the wild expanse of Ashdown Forest, stretching away to the west. Still ascending, Crowborough was at length reached, and standing on the summit Mr. Lobley reminded the Members that they had now arrived at the anticlinal axis of the Weald, from which the beds dipped north and south; that they had traversed first the long northern slope of the Chalk ridge of the North Downs, had then descended its steep escarpment on the southern side, crossed the Gault vale and, at Sevenoaks, the Lower Greensand ridge, and then the Weald Clay valley of the Medway, followed by the Tunbridge Wells Sand ridge and the Wadhurst Clay vale, from which they had ascended the great swelling mass of Ashdown Sands, on which they now stood. The parallel ridge and valley character of the country had been well seen; the long slopes and the escarpments, the varying character and appearance of the country, and the change of vegetation following the change of formation had been noted. His task, which was to conduct the Association from the London Tertiary Basin to the summit of the Weald, was now completed, and congratulating those who had attended this series of Field Meetings on the fine weather with which they had been favoured, Mr. Lobley expressed his thanks for the co-operation and support of so large a body of the Members during the five days he had had the pleasure of their company in the fair counties of Kent and Sussex. Professor Morris remarked on the absence generally of gravel beds in the Wealden area, and said that where these did occur they went to prove that the direction of the rivers had always been the same, though Mr. S. Wood maintained that the contrary was the case in

the north from the existence of "trumpet-shaped" gorges in the North Downs. He showed that if the Chalk had covered the Beacon, we should have to account for the denudation of some 8,000 feet, but possibly Crowborough Beacon was a bank in the Cretaceous sea. After alluding to the beds in the Boulogne district, he ended with a tribute to the zeal and ability with which Mr. Lobley had conducted the Association. The Members present expressed their very hearty thanks to their Director, Mr. Lobley, and to Professor Morris, and all then hastened to the Rotherfield Station to return to London.

EXCURSION TO LEDBURY.

MONDAY, JULY 21ST, 1879, AND FIVE FOLLOWING DAYS.

Directors—G. H. PIPER, Esq., F.G.S., President of the Malvern Field Club; and CHARLES CALLAWAY, Esq., M.A., F.G.S.

MONDAY.—The party on arriving at Ledbury were met by their Director—Mr. G. H. Piper, F.G.S.—and proceeded to examine the Ledbury Railway tunnel, about 1,700 yards long. At the W. end the Old Red is seen on either side at an angle of 75° south, and so continues for about 100 yards where it passes into the Downton Sandstone with passage-beds between. In the Old Red *Cephalaspis*, *Pteraspis*, *Pterygotus*, and other characteristic fossils occur. Beyond the Downton Sandstone come the Upper Silurians at first conformably, but afterwards much faulted and repeated as far as the east end of the tunnel, where they are covered with drift in which mammalian remains have been found. At the top of Ledbury Hill, a good view was obtained of the physical features of the surrounding country.

TUESDAY.—The Members visited the district of May Hill. They first examined the exposures of the so-called Longmynd rocks, described by Sir R. Murchison as occurring near the village of Huntley. These are dark grey, purplish, and greenish compact rocks, with a high dip, and are well exposed in a quarry on the roadside. The opinion of the Members, conversant with the Longmynd rocks in other areas, was that they resembled those rocks in their mineral character and state of induration. They could not, however, after their previous examination of the Malvern Hills, subscribe to the

following opinion expressed by Sir R. Murchison in his later editions of "Siluria"—"Seeing that this boss of old slaty rock is directly upon the southern extension of the ranges of the rocks forming the Malvern Hill, I would adduce this fact as a support to the conclusion I have already drawn—that the crystalline and schistose nucleus of those hills is of Cambrian age." This was expressed long after Dr. Holl's paper on the Malvern Hills was published, and contained, therefore, probably his latest view. The true reading, according to present knowledge, seems to be that these are the oldest Palæozoic rocks in the neighbourhood, and that the materials of which they are made were derived by the denudation of gneissic and chloritic rocks, similar to the pre-Cambrian rocks now exposed in the Malvern chain. In the hill side, about a quarter of a mile further towards May Hill, the conglomerates and sandstones of the May Hill series come on abruptly, and, probably, partly as the result of a fault. Higher up on the right hand side two large quarries occur, and here the rocks are beautifully exposed. The beds are at a low angle, and consist of alternations of sandstone and friable yellowish shale, the latter usually full of fossils. In ascending May Hill from this point several exposures of similar rocks were observed, but no further sections of any importance.

WEDNESDAY.—By train to Knightwick Station, where permission was freely afforded to examine the remarkable cutting in the older rocks which commences at that point, and continues west for some miles. On the geological map of the Ordnance Survey, 55 S.E., it will be seen that a long "line of fault," which begins far down to the south on the right bank of the River Severn at Preston Passage, and running between the Forest of Dean and the right bank of the river, extends as far north as Abberley, a distance of nearly forty miles. The line, as usual in very long faults, is not straight but curved considerably at several points; it forms a marked feature on the eastern side of the Malvern chain, faulting the older rocks against the Triassic beds. As this fault approaches Knightwick, it throws off a small branch fault about three quarters of a mile long to the N.W., and which appears to end on the bank of the river Teme, about half-way on this branch fault another short fault strikes off to the N.E., and about a quarter of a mile long. This short fault runs into the great forty miles N. and S. fault. There appears to be another fault, making four, at

this point, but not laid down on the Survey map (being concealed by overlying drift beds), but opened out in the cutting at Knightwick Station. These four faults have brought together, within a distance of less than 600 yards, beds from the Upper Trias down to the Lower Silurian. The cutting appears to pass through the central portion of these faults. Of the entire section, certainly the most notable point is the letting down (or thrusting up) of a mass of supposed Llandovery age, wedged between the base of the Permian and the base of the Old Red. It is very difficult to understand how this came about, the whole four faults (showing the various formations dipping at different angles) certainly could not have been produced at one operation. We should be inclined to consider that four different disturbances at least, at widely separated periods, had occurred, and this particular spot seems to have been a *focus* or crossing place. Of these independent disturbances, it may be noted that the Carboniferous rocks, of which none are actually *seen at any of the faults*, are well known to underlie the Permians of this district. This is seen at Oxenhall, near Newent, where coal-seams are now being worked, this is some miles *south* of Knightwick, but again these same rocks are seen two miles *north* of Berrow Hill, where they crop out under the basement of the Permian. So there can be little doubt at the third fault several thousands of feet of rock have disappeared.

THURSDAY.—After luncheon the party walked to the valley of the White-leafed Oak. On the western slope of Ragged Stone Hill the Black Shales were noticed, and some specimens of *Olenus* were collected. At the south end of the hill the so-called anticlinal was examined. It was found not to be a true anticlinal, but, as previously shown by Dr. Holl, was simply a junction of the Hollybush Sandstone with the gneissic rocks of the central ridge, the sandstone dipping westerly and the schists easterly. The Dictyonema Shales were not visited, but specimens kindly collected by Mr. Piper were exhibited in Ledbury, and Dr. Callaway identified in them *Macrocystella Mariæ*, Call., a cystid not before recognised out of Shropshire, forming an additional link connecting the Dictyonema beds with the Shineton Shales of the Wrekin.

FRIDAY.—Investigation was mainly confined to the ancient rocks composing the central ridge of the Malverns. After a glance at the gneissic strata exposed in a quarry at the Wind's Point, where

Dr. Callaway and Dr. Hicks gave a brief account of the structure of the chain, showing that it was made up of highly altered pre-Cambrian beds striking across the axis, with younger strata resting on the flanks on each side, the party were led to the "baked rocks" of Dr. Holl, which formed several spurs springing from the eastern side of the Herefordshire Beacon. These rocks were quite different from those of the main chain, and, as Dr. Callaway had recently discovered, closely resembled certain of the Shropshire pre-Cambrian strata at Lilleshall Hill, near Newport, which he supposed were of Pebidian age. Prof. Bonney had also independently recognised a younger pre-Cambrian group in these rocks. They were seen to consist of felspathic material, generally very compact, with a horny fracture, and in places brecciated, but in the lower part (near the main axis) they were darker in colour, and less indurated. Dr. Hicks agreed with Dr. Callaway's identification.

Starting from the Wych, the party walked along the ridge to the Worcestershire Beacon. Dr. Callaway here pointed out the granitoid composition of the northern part of the Malvern chain, which confirmed, in his opinion, his view that these granitoid rocks were the equivalent of the Dimetian of St. Davids, Carnarvon and Anglesea. In places this granitoidite was very coarse-grained, and seemed to have originated in the metamorphism of a breccia. Dr. Hicks, also, was struck by the resemblance of these rocks to his Dimetian group. Associated with these more massive beds were bands of mica-schist, and of clearly foliated hornblendic gneiss, striking across the ridge. The Malvern "diorites" were also observed. These crystalline compounds of hornblende and felspar were so closely associated with hornblendic gneiss as to suggest that the "diorites" were simply the gneiss in a state of more complete alteration. On the western slope of the North Hill, a band of decomposed greenstone, resembling the green bands in the Dimetian of St. Davids, was noticeable.

SATURDAY.—The party drove to the Woolhope district. As the time was short, there was not much opportunity for inspecting the sections, but a good view was obtained of the physiography of this classical locality, with its concentric series of Upper Silurian limestone escarpments ranged round a central anticlinal of Upper Llandovery Rock.

ORDINARY MEETING.

November 7th, 1879.

Prof. T. Rupert Jones, F.R.S., F.G.S., President, in the Chair.

The Donations to the Library received since the previous meeting were announced, and the Donors received the thanks of the Association.

George Bond, Esq., was elected a Member of the Association.

The President then delivered the Inaugural Address of the Session 1879-80 :—

On the Practical Advantages of Geological Knowledge.

CONTENTS.

§ I. Introduction.—The Science of Geology is closely connected with all the other Natural Sciences, as we term the many systems of knowledge that have as objects of study the several aspects of Nature, and the various conditions and relations of Matter, animate and inanimate.

Astronomy, Geography, Zoology, Botany, and Chemistry are especially and intimately associated with Geology in the systematically arranged results of intellectual research known as Natural History; and all the parts of this wide circle of the Sciences centre on a knowledge of the Earth, its relation to other bodies, and its composition.

Whatever our line of life, we have all to recognise, if not to study, in some aspect or other, the relations of Man to the Earth, to its various products, animate or inanimate, to its Atmosphere, and to the Solar and Astral Bodies among which it is placed, as well as the relations of these one to another.

The Astronomer expounds the laws which regulate the movements and appearances of the Stars, the Planets, and the Earth; and thus he guides the Sailor and the Traveller, and gives us a knowledge of much that belongs to the physical constitution of the Globe on which we live.

The Meteorologist deals with the laws of Storms and of Climate, the origin and formation of clouds, rain, and snow; and endeavours to make practical his accumulating information concerning atmospheric phenomena.

The Chemist handles the *Materials* of which the Earth, its Atmosphere, and its Inhabitants consist; and by reducing them to their Elementary parts, and finding the behaviour and relations of these constituents to each other, he makes them enter into new combinations, useful in the arts; he illustrates the hidden actions of Heat, Electricity, and Crystallization, and presses close upon the mystery of Nature's secrets, the ultimate condition of Matter and Vital Action. The laws of Light and Heat, Gravity and Motion, and the correlative Forces, occupy the thoughts of many, and must be well understood for the proper guidance of thousands of the operative portions of the community.

The Living Inhabitants of the Earth, whether of the land or sea, whether growing Plants or breathing Animals, have to be known, as an important part of the great system of the Universe, in their relations amongst themselves, and as sources of innumerable benefits to Man in his many different conditions on the earth.

All branches of Science, then, have a direct bearing on the Earth itself. The Planets and Stars are to be studied in relation

to our Globe, its constituents, and its physical conditions of form and density. Meteorology cannot treat of Winds and Clouds without Physical Geography—that is, a knowledge of the Earth's surface; and this surface, with its endless variations of feature, with its innumerable Living Beings, owes its form and characters to the *inner structure* of the Globe. Chemistry and Natural Philosophy, teaching the nature of things found in and upon the Earth, and Zoology and Botany (or Biology), treating of Life and its various modifications, animal and vegetable, all necessarily have, intimate connection with the Earth, its form, and its constituents. Thus Geology, to which all the above-mentioned sciences may be said to be accessory, receiving full elucidation from them tends in many ways to the direct benefit of Man.

And let us remember, too, that it is as much better to study the high lines of Science than pore over the common circumstances of life, as it is to live for moral purposes rather than for mere physical existence.

§ II. Classification of Geological Subjects.—The following may be taken as a sketch of one of the classifications (and there are many) by which geological facts and theories can be grouped together for the convenience of students:—

Geognosy (Erdkunde): a scientific knowledge of the Earth. The word " Geology " is generally used in this sense.

1. Mineralogy and Crystallography. The study of rock-forming minerals.

2. Petrology and Lithology, including Micro-geology, Mineralogical Histology, Clinology (Schafhäult), or Micrographical (Microscopical) Geology. The study of the external features and the intimate constitution of rocks.

3. Stromatology, Stratigraphy, or Stratal Geology.* The study of the relative position, successive arrangement, and structure of rocks.

4. Dynamical Geology. The study of natural forces as effecting geological changes and results.

5. Experimental Geology. The study of artificial means in illustrating geological and mineralogical conditions.

6. Physiographical Geology, Physical Geography, or Terrestrial

* Clinology would have been applicable, but it has been used for Micrographical Geology.

Physiography. The study of the Earth's Surface as respects the causes of its geographical and hydrographical features, and of its meteorological and biological conditions.

7. Palæontology. The study of Organic Remains, animal and vegetable.

8. Historical or Successional Geology. The study of the constituent parts of the Earth's Crust, in their order, from the most ancient to the newest formations.

9. Applied or Practical Geology.
   1. Geogeny (Géogenie) ; explanation of the origin and conditions of a given mass or area.
   2. Economical application of Mineralogy, Lithology, and Geology in general.

Of these divisions there are two which may here be further subdivided, as their subjects concern people in general, and are especially the objects of this Address First :—

I. As Cosmography implies the scientific description of the physical system of the Universe, so Physiography means the scientific description of the *nature* of any thing or set of things. The Earth's Physiography is " Terrestrial " or " Tellurian Physiography ;" but sometimes the word " Physiography " alone is used to express this, and means something more than the older term, Physical Geography. Its sub-divisions take the following form :—

1. The Earth as a Planet and Terraqueous Globe : its place in the heavens ; movements, shape, size, specific gravity, constituents, heat, &c. The relations of Terrestrial and Celestial Physics.

2. The Atmosphere : its composition, character, movements (winds, &c.), temperature, moisture (clouds, rain, &c.) ; Climates, present and past. Meteorological connections and relations of the Earth's surface. Light : Electrical phenomena, &c.

3. The Waters : Hydrology and Hydrography.[*] Rain and snow ; watersheds ; drainage ; rivers and lakes ; water-supply (natural and artificial) ; springs, sweet and mineral ; seas and oceans ; oceanic currents, &c.

4. The Land-surface. Geography and Topography. Mountains

[*] These should be, but are not quite, analogous to *Geology* and *Geography*.

and Hills, their height, form, structure, passes, snow-line, &c. Valleys. Plateaus. Plains. Coasts, &c.

5. Electricity and Magnetism.

6. Distribution of Plants and Animals (Biology).

II. Applied or Practical (Economical) Geology.

1. Form of Ground (Topography) explained geologically.

2. Fertility or Barrenness of soils and rocks: special plants and animals on particular soils and rocks.

3. Drainage and Water-supply, natural and artificial.

4. Supply and choice of Building Materials.

5. Nature of Foundations and Earthworks.

6. Road-making; choice of line and of metallings.

7. Fossil Fuel: Peat, Lignite, Coal, Anthracite, &c.

8. Metals, Metallic Ores, Gems, &c.

9. Making Geological Maps and Sections; and drawing up definite descriptions.

§ III. Practical Geology.—From our childhood, even, we all begin to collect information about the several departments of Nature—about the Heavens and the Solar system, about the Atmosphere and the topographical features of the Earth, about the nature of fire, light, magnetism, and gravity; and among the earlier observations of boyhood, at home and in the fields, are those made about birds, beasts, and fishes, insects and reptiles, flowers and trees. Nor is there wanting a natural curiosity as to the different stones, minerals, and fossils seen in the garden and fields, or found on the beach or in the quarry. Here, then, is the elementary ground-plan of the Natural Sciences, laid out, as it were, in early life as a basis on which the perfect temple of knowledge may be built up in succeeding years by each individual.

It is plain that this power of observing (greater in some than in others) is given to us that we may learn to recognise and explain the nature of things, and apply the results to the Public Good. But we cannot all do everything; each must take his special branch of knowledge, his definite line of research—that is, he must follow his own Profession. As each department of Science, however, is connected with the other, so are all intimately connected with that branch of knowledge of which we are *Associated Students*, namely, *Geology*—a science which has of late years reached its present standing, after a long infancy, as it were, wait-

ing for the growth and perfection of the sister sciences; for though in the works of the earliest Naturalists we find notices of minerals and of fossils, these were little, if at all, understood—just as the child may treasure among his earliest trinkets the pretty pebble, long before he knows anything of its natural history, thinking of it only as a member of the toy-family, invested by his child-notions with a fancied importance and special value.

Before Chemistry was well cultivated little could be really learnt of the nature of minerals and soils; before Biology had been extended beyond its ancient limits into the well-known, comprehensive, and classified sciences that Zoology and Botany now are, the petrified remains of Animals and Plants were obscure, often misunderstood, or regarded merely as mysteries, curiosities, or rubbish. Before the Astronomer and Physicist had learnt the laws of matter and of motion, the notions regarding our Globe as a planetary body were wild and sometimes worse than useless. Now, however, the shape, size, density, and other properties of the Earth are correctly known. The structure of that portion which is open to examination is understood; the relative places of the different mineral masses, and of the various kinds of fossils, are known; and, what is more, this knowledge is now applied to useful purposes. And not only may we study the Science as an intellectual exercise, as a source of mental gratification in the working out of its problems and learning the wonderful history of this planet's surface, but as means placed by the Creator within our reach for contributing on every hand to the interest, advantage, and comfort of Man.

How could we get on without Mining, Engineering, and Building? Though much has been done by miners, engineers, and architects without scientific knowledge of Geology, yet much more might have been done in time past. Much better results of their labours would have accrued had they possessed this knowledge, and immense waste of time, labour, and money would have been avoided. We see that this is true by what takes place sometimes, even at the present day, when the laws known to exist in nature as regards the structure of the Earth are ignorantly opposed.

What makes Agriculture now-a-days to be totally changed for the better as compared with the practice of farmers of olden time? A recognition of geological conditions has been concerned in this in more ways than one. The relation of Geology to Agriculture

is well shown by the following extract from the "Geol. Survey Wisconsin," Vol. ii, 1877, p. 41 :—"The law providing for a Geological Survey of the State of Wisconsin includes also, and very properly, provision for some work for the special interest of Agriculture, it being now generally known and admitted that these two subjects are so intimately related that whatever is done to increase our knowledge of the local and special geology of any district tends, at the same time, to promote the interest of the farmer cultivating land in the same district. The underlying rocks are examined as to their chemical composition and their surface arrangement, or geographical extent; they are the sources from whence is derived the very soil into which the farmer annually intrusts his seed. Their dip, order of succession, depth beneath the surface, their porous or impervious nature; these are the data for deciding about artesian or other wells, often the only resource for a permanent supply of water for the farm purposes; and as the forests become reduced in extent, the necessity for such wells will be gradually increased. The drift phenomena, gleaned from an extended and careful study of the loose materials covering and concealing the more solid rocks, left here by the glaciers of the ice-period, the study of which is so interesting to the practical and the speculative geologist, have been the means of diffusing and their spreading the soil over the rocky surface, commingling and mixing the various clays, sands, and pebbles derived from the disintegration of the rocks, in such manner as to render them the best suited for the growth of vegetation. The mineral and other native resources are discovered and made known; they are the material for various manufactures, and their development creates a home market—the best of all markets—for farm products; thus deciding the great question, now so much agitated, relating to cheap transportation, by avoiding the necessity of any transportation of these products."

As in Agriculture, so in other things. The Geographer finds that the characters and variations of coast-lines and shoals are explained by Geology; that the forms and conditions of mountains and valleys are due to the internal structure of the rocky and earthy masses composing them; that rivers, lakes, and seas hold definite positions, due also to the structural peculiarities of the globe. The Landscape-painter, too, must study the characteristic structure of mountains and cliffs, valleys and

plains, as closely as the portrait-painter studies the features of his subject, and as the sculptor studies the anatomy of the human form.

There is scarcely any line of life in which a man does not find himself closely interested in the results of good mining, good engineering, good building, good agriculture, and a good knowledge of physical geography and hydrography. In town and country, at home and abroad, resident or travelling, by sight or use, or some form of contact, reading, or conversation, we have every day to do with some of the manifold phenomena and appliances of Geology and its intimately connected sciences.

Now-a-days, Universities, Colleges, and some Schools provide means for the technical education of professional geologists, mineralogists, and miners, and for the geological teaching of engineers, architects, agriculturists, and others who wish to be acquainted with this science. The Government also considers that a knowledge of Geology is to be regarded as an element in such a liberal education as candidates for Civil, Military, and Naval appointments should possess; indeed, the Authorities supply to some extent the means for a prosecution of geological studies by Military Engineers and Staff Officers.*

There are few, if any, members of society who have more opportunities of cultivating a knowledge of geology with benefit to themselves and their country than Military Men, for they are often as far-travelled as the most energetic tourist or Alpine-Club man, and are almost as frequently on the move as a professional geographer. Captain Hutton says:—"As Geology is the most useful of the sciences to a Soldier, so is a Soldier's profession the one of all others best adapted for its study" ("Journ. Unit. Serv. Instit.," Feb., 1862, vol. vi., p. 342).

The Consul, the Missionary, the Colonist, the Traveller, the

* In the "Manual of Field-Fortification, Military Sketches, and Reconnaissance," 1871 (8vo., London), published by authority, the following observations occur in a note at page 156:—"There can be no doubt of the value of the knowledge of geology in operations of this nature [drawing up a Report]. The form of ground and the features of the country are influenced by the geological nature of the soil; and an officer who is acquainted with the different forms which the surface of the earth assumes according as it is composed of chalk, gravel, or plutonic rocks evidently possesses an additional element of facility in sketching and describing country. Moreover, any geological information which may be embodied in the report of a reconnaissance cannot fail to contribute both to its general usefulness and interest. In the present day, indeed, a survey and report upon a country would not be considered complete unless it contained some amount of geological information."

Tourist, the Yachtsman, and individuals of the mercantile and naval Marine, especially on explorations and surveys, have brought or sent home the scientific results of laborious travel and acute observation, often of great importance in Geology, and sometimes well systematized, but often fragmentary or otherwise imperfect. The Army, also, in its several departments, has not failed to collect and supply much valuable geological information from many parts of the world; but how much more extensive, more perfect, more valuable would these communications have been had Geology been more insisted upon in the training and maturing such a body of useful and wide-spread intelligence and power as the British Army!

The common elements of education, a sharp observation, and the application of common sense may help some in noticing and appreciating geological facts and inferences; but to give trustworthy and applicable results, an observer, whether civilian, naval, or military, requires a far more complete acquaintance with rocks, minerals, and fossils, and with the laws governing the formation of the Globe, the conditions of land and sea, and the relations of Man to the Earth, than he can pick up by unguided observation * and general reading.

To make this still more evident, I propose to point out—Firstly, in what respects a knowledge of Rocks and Minerals is useful to a Traveller, whether in long or short journeys, whether amateur or professional; and for this purpose I cannot do better than keep before me the idea of a *Military Officer*, liable to be called away to any part of the world, and requiring all the useful information about places and things that he can get together accurately and systematically. Secondly, we shall see how a knowledge of the structure of Stratified Rocks will help such a one.

If my examples and instances sometimes show where and how errors and loss might have been avoided, and that, if fore-warned by geological knowledge rightly used, the Soldier, the Engineer, the Traveller would have been fore-armed, I point out a good road for them to follow.

If I show that a knowledge of nature can and must direct a

* There is, I say, a strong liking for a knowledge of the earth and its structure, and hundreds have availed themselves of this natural, intellectual exercise with pleasure and good results; not but that sometimes a limited knowledge, urged by self-conceit, has produced weak statements and very unsatisfactory hypotheses, showing that a little knowledge, badly applied, is detrimental to the advance of science.

Military Man and others to right and quick decisions, they cannot but think well of Geology.

If I connect the form of ground with Geology, and show why and how certain features have been given to those spots and regions where kings and peoples have played the game of war—the formation of the chequers of a great and much-used chess-board—surely you will find an interest in it; for there must be few, if any, minds—none that are educated—but wish to know the reason of all these things—the reason, for instance, why the hills *here* rise up like quiet downs, and *there* are buttressed by rugged ribs! It is only the pre-occupied, ennuied, and thoughtless that pass through railroad-tunnel and river-valley without wishing to know something of their origin and construction. So of a battle-field—there is much to be learnt of its being laid out as a plain, or ridged with hillocks, cut up by gullies, ravines, nullahs, or dongas, traversed by the river, backed by the hills, or overlooked by the mountains—in fact, its primæval history, and why it came to be so good or so bad a field.

Geology is highly important to the Soldier as a branch of Military Art. Essentially the Science of War deals practically with the manifold conditions of the Earth's surface. All the calculations which, summed up, constitute the Art of War, and on which the successful issue of a campaign depends, are based on the nature of the country in which the operations take place—that is, on the character and military value of the physical features of the *terrain*. *Strategy*, the principle on which the greater movements of an army are conducted previous to an actual collision, has been defined as the "Science of Roads." It is self-evident that roads in every land and in every instance conform to the physical—that is to say, the geological—aspect of the country. Mountains produce defiles and gorges, through which the great arteries of traffic must inevitably run, and low-lying countries, intersected with morasses or with irrigated fields, have their roads confined to certain definite lines, marked by the presence of harder and drier soil; and all these peculiarities are within the province of, and part of, the studies of the Geologist. Rivers, the other great highways of commerce and intercommunication, are among the most important of military obstacles, and streams and rivulets, lakes, and even ponds, are not scattered haphazard over the earth's surface, but conform to natural laws, which lay down their positions and courses on broad

geological principles. Water, seeking the lower level, finds naturally the easiest course, and winds through its areas over those portions of rocks and strata which offer to it the least resistance. Thus, wherever the rivers run, valleys of greater or less importance are found, simply because the very presence of these hollows, worn by ages of decay and denudation, on account of original cracks and fissures in some cases, and soft material in others, indicates the easiest path by which the rain, snow-water, and springs of the higher lands can seek the sea.

In the other branch of the Soldier's Profession—that of *Tactics*—the value of Geology to the General and his Staff is equally manifest. The occupation of a position for defence, and the plan adopted for the attack of one held by the enemy, must be based on considerations of the ground—that is to say, on the physical aspect of the theatre of war.

Every geological formation, every different substance which goes to make up rock-masses, or to produce undulations on the surface, has certain definite peculiarities, which are only modified in detail. The situation of a village, the nature and extent of woods, the abruptness or gentleness of the hill-sides, all depend, to a greater or less degree, on what lies beneath the surface; and however concealed the essential structure or constitution may be, to the mind of the Geologist, accustomed to seek a reason for variations and "accidents" of surface, these are but questions which he can refer to fixed principles, because they are based on unchanging laws. Take for example the reading of a common map for military purposes: the roads, rivers, and mountain-lines are indicated with accuracy and care, but the nature of the cultivation, the practicability of roads for the transport of heavy trains, the value of the hill-sides for defence or for camping-grounds, cannot be told without a reconnaissance and a careful detailed report. When, in addition to the other information afforded to the General by this map, the geological character of the area is pointed out on it, much more and very valuable information can be gathered by eyes skilled in interpreting the nature of the materials of which the land is there shown to be composed. Whether their principal constituent be sand or clay, whether the rocks be hard or soft, thus giving the nature of the declivities, would all be indicated; and though there might be many minor varieties of detail, of a more or less unimportant character, the broad general nature of the

country through which operations were to take place would be understood, and the preparations for movements (by a correct estimate of labour and means) could be made much more completely applicable than if this geological knowledge were wanting.

In studying the *applications* of geological knowledge, we recognise that Geology divides itself into two chief branches. In the first place—

The *structure* of the Earth forms the subject of that department known by some as *Descriptive Geology;* and this is divisible into two parts: I. About *Rocks* of all sorts; and this also divides itself into two branches: 1. First, the study of the *general aspect and characters* of "rocks" is that called *Petrology*, and rests on the still more essential knowledge of the *composition* of rocks—that is, of all the mineral masses composing the Earth, whether they be stony, like limestone and flint, or earthy, like clay and sand. This latter branch of the Science is termed *Lithology* for the sake of distinction, and comprehends what is known as the *Mineralogical* study of the Earth's material. The science of *Mineralogy*, by which Minerals or the constituents of rocks are classified and known, is intimately connected with *Chemistry*, by which the ultimate composition of Minerals is discovered, and with *Crystallography*, or the scientific description and classification of the endless varieties of crystalline forms of bodies, either occurring in the Earth or resulting from chemical processes in the laboratory.

2. Another division comprises the determination of the relative position, external characters, and mode of origin of the rock-masses which compose the Crust of the Earth, rising up into mountains, stretching out as plains, or forming the hollow floors of valleys and seas. This is "Stromatology" of some, "Stratal" or "Stratigraphical Geology" of others, and treats of the succession of the many different layers and masses forming that part of the earth which can be observed in cliffs, mountain-sides, gorges, and river-banks, and in mines, wells, road-cuttings, and other diggings. This order of succession is determined by considerations based on (1) mineral conditions, (2) relative positions of strata and veins, and (3) the characters of the fossils, if there be any present.

II. The second great department of Geology has reference to Fossils and the study of their character, both as mineral masses and as the forms of once living beings, related, as animals and

plants, to the general system of Life with which the Creator has populated the Globe. This is Palæontology.

There are many theoretical points of great interest—nay, even sometimes possessing the fascination of romance—connected with Geological science. There are, indeed, many points in what may be termed the History of the Primæval Earth that may be studied for the sake of the pleasure which the educated mind can receive from the explanation and linking together of facts, novel and extraordinary to those who know only of the natural processes and beings of to-day. Interesting as these are, they form but a part of the great system of Nature, and represent, as it were, only one illustrated page, and that a late one, of the great Universal History.

At present, however, the Economical Applications of the Science are of importance to us; and to this end we will first take into consideration the lithological materials, or earthy and stony rocks we commonly meet with.

§ IV. Materials : Limestone.—Rocks and minerals may be treated of as "Materials" in the first place. As such they may be classed under these types—1. Limestones; 2. Sandstones; 3. Clays; 4. Slates; 5. Granites; 6. Coals. In some shape or other these substances and their many modifications, occur in every country; in various associations in *large* areas; in *small* areas sometimes as isolated masses of one or the other substance. They all have their special appearances at the surface of the ground, and they have their special uses. To be able to recognise these materials and to apply them to these uses, it is necessary to know their characters and peculiarities.

Some varieties of these substances have very similar features, and yet are essentially different. Some white limestones or marbles look like compact sandstones or quartzites. But nothing is easier than to distinguish them; and often the decision as to whether we have a lime-rock or a sand-rock before us is highly important.

A traveller (Dr. Atherstone) in the Eastern Province, South Africa, chats with a Boer about his farm near the Loorie River. The Dutchman complains of bad times and want of lime; he has to send his team of treck oxen to a long distance for "Kalk Klippe," to be picked up on the flats; and these waterworn stones (the wreck of a limestone ridge) are getting rare. The traveller tells him that the precipice behind his house is all *Kalk Klip*. He

takes one of the "Kalk Klippe" and with his acid-bottle shows that it effervesces, and he shows the same of the rock close by. The latter is indeed a good limestone,* though somewhat magnesian, and really the same as that of the extended and distant ridge whence the Klippe used to be laboriously fetched by waggon!

This was the case of a Dutch Boer; but were they any better as to geological and practical knowledge who ("sending coals to Newcastle") sent limestone (soft and perishable) from Malta to Corfu, which yields a better stone, for building the Government House (*auth.* Gen. Portlock, R.E.). So also, in Sir — Cochrane's time, the Government Houses at St. John's, Newfoundland, were built of granite brought from Aberdeen—granite forming the ground hard by! (*auth.* Gen. Portlock.) Flagstones from Forfar have been used in Halifax, Nova Scotia, though similar flags occur in the neighbourhood. ("Journ. Instit. Nova-Scotia.")

Similarly unscientific, at least, was the taking of highly dangerous cargoes of lime from Plymouth to Bermuda, which itself is formed of calcareous (coral) rock, instead of coal to make lime with there. (*auth.* Gen. Emmett, R.E.) Possibly the inconvenient conditions for fuel and limekilns at Gibraltar are the reasons why seaborne lime, instead of coal, has been taken to that great mass of limestone.

Limestones differ among themselves according to the amount of natural cement between the particles of shells and such like component bodies, and on account of the presence of other materials besides carbonate of lime. Thus one kind of oolitic, or of magnesian† limestone may be good for building, but others, passing under the same name, perhaps, are nearly worthless. Witness the lasting buildings of oolite from Portland‡ and Brill, and the decaying oolites

* The so-called Maitland Mines, near Port Elizabeth, were made in this great range of limestone—"Many thousands of pounds have been sunk in a reckless and extravagant manner, when two or three hundred pounds would have been sufficient to prove the worthlessness of the site as a mine." Galena, blende, and copper-pyrites, &c., scattered and in quartz-veins, occur, but nothing like a real lode. Dunn's Geol. Report, "Cape Monthly Mag.," new series, Vol. i., July, 1873, p. 60, &c.

† Magnesian limestone has a *soluble* sulphate of magnesia formed on it in London by the atmosphere charged with smoke-gas; and thus its surface is easily disintegrated by rain and frost.

‡ Sulphate of lime, white and insoluble, is formed by sulphurous acid of the London air on such limestones. The black portions are not coloured merely by smoke, but probably by a black *Protococcus* ("Journ. Microsc. Soc."). The degradation of this limestone by rain and carbonic acid, how-

of Oxford. Even the same band of limestone necessarily varies in character mile by mile across the country; for the shell-banks of which it was made varied from living shells to dead shells, broken shells, shell-grit, and shell-mud, along their range. The lasting qualities of limestone can be readily tested; a knowledge of the origin and mode of formation of limestones can alone satisfactorily prepare anyone for choosing a limestone or marble with judgment.

Of course, pure limestones, whether old and hard, or soft and recent—formed of massed Coral-reefs and Encrinites, or of scarcely adherent Shells and Polyzoans—will all show the same results when tested with an acid, will all burn to quicklime, and will serve, more or less fitly, for building, and even for road-metal, if nothing harder be at hand. But where there is a choice, judgment must be used.

Black marble and black lydianstone (touchstone) may look much alike; but, even without the acid-bottle, a hammer, a knife, a file, or even a steel-pen will prove them: for steel will not scratch quartz, but will readily make its mark on any form of calcite. So dark green serpentine and green jasper (bloodstone) may look alike, but they differ greatly in hardness, &c.

In the Grecian Archipelago and the Sea of Marmora you will find white marble and white quartz-rock. A ship-load of one instead of the other would be a bad venture!

The "Kunkur" of India, often the only source of lime for large districts, is found in the soil and has resulted from the decomposition of land-shells, old river-shells, bones of drowned animals, and washings from distant rocks, the river-water and the percolating rain having rearranged the calcareous particles among the alluvial mud. Now, it is due to the presence of the clay with the lime in the "Kunkur," that this partakes of the character of *hydraulic lime*, and requires special processes in its application to road-making and other requirements in India.

Waterlime and hydraulic cement are frequently obtained from *nodules* and layers in great clay-beds, like the Lias, the Oxford and London Clays, &c., where the lime of shells and bones has accumulated along certain lines in combination with clay and iron. These are washed out of the cliffs at Lyme-Regis, Whitby, Wey-

ever, is considerable, for the cement stands up in edges, an inch high, on the parapet of Somerset House, and the component fragments of oyster shells almost as high.

mouth, Hengistbury, Harwich, and elsewhere, and are dug out in many railway-cuttings; and are not always left to lie useless.

Not being prepared to calcine such cement-stones for use, the Engineers, constructing the forts on the Hampshire coast, used those that were dug out of the foundation for road-stones; whilst on the contrary the contractor making the great sewer at Peckham used for cement the argillaceous-Paludina limestone excavated on the spot.

The formation of an insoluble silicate of lime in the wet mass is, of course, the essential condition of a cement to set under water; whilst the crystallization of carbonate of lime by absorption of carbonic acid is the process in common mortar. Varieties of this occur with the varying quantity of clay in the limestone, and with the differences of preparation. Where common limestone and marble are absent, accumulations of land-shells, as at Madeira and on the volcanic islands off the Neapolitan coast, serve instead; also marine shell-heaps, whether exposed by the last uprise of the land from the sea, or accumulated by aborigines, are sources of lime.

§ V. SANDSTONE.—Without speaking further of chalk, oolite, and other limestones and marbles as building-materials, and passing over their stratal conditions, we will note of Sand, Sandstones, Grits, and Conglomerates, that a necessary material in the mortar for building is to be sought for in sharp sand, free from salt; also that very fine sand is good for castings in foundries, pure siliceous sand for glass-making, and sharp sand for grinding, polishing steel, &c.

Sandstones (mostly consisting of grains of quartz) are often friable enough to yield loose sand, cementation being at the minimum. Sandstones are bad for lines of canals (as they are porous and require much "puddling"), also, if loose, for roads and road-metal. If their material be coarse (grit or conglomerate) and compactly cemented by iron-oxide, carbonate of lime, or silica, they are more or less serviceable for road-stuff. Siliceous gravel with plenty of iron-oxide is much used for roads and paths. Some millstones and grindstones consist of grit; some of porous chert, the *meulière* of Paris (a pseudomorph after limestone). Novaculite (a very fine-grained quartzite) and lydianstone (a metamorphosed shale) serve for honestones and touchstones.

In the form and condition of sand-dunes, sand both destroys

many acres of cultivation, and preserves many miles of coast from the ravages of the sea. The sand-dunes have been strengthened, established, and preserved by the growth of the Sand-grass or Marram (*Arundo arenaria*), in Holland especially; and by the planting of Pine forests along the Bay of Biscay, where the turpentine of these Pinasters is a source of revenue. Casuarina also has been similarly used against the encroachments of sand.

As a destructive agent, blown sand pours over an unprotected coast, or from a desert—as over Egypt—until natural or artificial watering and vegetation stop it. After unsuccessful attempts to check the advance of the sea on the Norfolk coast, it was taken in hand by the famous Geologist, Wm. Smith (whose "Life," by J. Phillips, shows several successful applications of geological science). He copied nature, and, knowing how the sea made sloping banks of sand and pebbles that resist the action of the waves, he made dams like them, and they still stand.

The accumulation of shingle (that is, pebbles and sand) by properly adjusted groins is also worthy of remark. The Isle of Portland is a great groin, keeping up the Chesil Beach. Groins placed, by order, at Dover, with the correct angle, but in the wrong direction, of course did more harm than good. (*auth.* Gen. Portlock, R.E.)

As sand cemented becomes sandstone, often so evenly constituted as to be a "freestone," so sandstone still further compacted (by pressure, with partial softening of the grains) becomes quartzite, too hard for general work. The other common quartz-rock is Vein-quartz. Pure white hard quartz-rock, so hard to the chisel, will not yield in solution or degradation, even to the Lichen; and therefore preserves its white cappings on the Scotch mountains, and in Africa, America, and elsewhere; being sometimes mistaken for snow—making "Snowy Mountains" for the maps, maybe, where no snow lies.

The study of the influence that limestones and sandstones have in the features of a country comes under Geological Topography.

§ VI. Clay and Shale.—These are very valuable materials. Their chemical basis is alumina (the oxide of aluminium), with silica (the oxide of silicon). The ornamental sapphire and ruby, and the useful emery, consist of *alumina* itself; but clay has another component besides. Nonsensical rhodomontade is sometimes found in newspapers about clay being the vulgar and dirty

form of sapphire! Felspar is also composed of alumina and silica, together with soda, potash, or lime; and it is an abundant source of clay. Cryolite (scarcely to be distinguished by sight from other subtranslucent white minerals) is a fluoride of aluminium and sodium; and is one of the principal manufacturing sources of aluminium. Bauxite, looking much like brick, is an aluminate of iron, and is another source of this elegant metal.

Some forms of quartz, calcite, and felspar resemble one another sufficiently closely to puzzle the tyro; but they differ in hardness, specific gravity, crystallization, mode of breaking, and in other properties and characters, easy of recognition.

The plastic clay called "kaolin" and "pipe-clay," used for china-ware, &c., is derived from felspar by either natural or artificial degradation. Potter's clay, for coarse pottery; brick-clay, brick-earth, or loam, for stock-bricks; sandy clay for soft reddish bricks; very tough clay for tiles, &c., are natural modifications of disintegrated felspar and felspathic rocks.

Bricks are of such great importance both to Civil and Military Engineers that they must know where to look for brick-earth and be able to judge of its relative value. It is found at the foot of some hills, in depressions and valleys, with or without rivers, where either clay-ground has been disintegrated, or clay, sand, and chalk * (or other calcareous matter), from the higher grounds have been duly commingled by the great rainfall of the past (Pluvial Period). It often contains Mammalian bones of great interest.

The Medway and the Medina produce certain alluvial deposits good for making cement on account of the natural admixture of materials convertible into silicate of lime. The Medway washes down Chalk, Gault, and Neocomian sand. The Medina brings together washings from Chalk and from Tertiary clays and sands. The Thames deposits chiefly clay-mud from its banks of London Clay, &c.

A very pure clay (without lime, magnesia, or iron—but with hydro-carbon or carbon, which quickly burns off) used for making fire-bricks, is abundant in the Coal-measures, and in other carbonaceous deposits (Scania and Alum Bay). It is known as "fire-clay," "under-clay," "seat-earth," &c., as it underlies the seams of coal or lignite. Its geological history is of high interest.

* This gets segregated into nodules or "race,"—analogous to "Kunkur."

Some shales associated with coal, as well as other shales, are pyritous, and are made to yield alum; others are so rich with hydro-carbon as to give paraffin by distillation.

Burnt clay is good for paths and road-bottoms, and for ballasting railroads. The clay is dug in lumps, carefully piled and dried, stacked with fuel, and slowly burned like brick-clumps.

Many bedded clays contain cement-stone and ironstone. Were it not for definite official instructions and specifications which could not be put aside, there might have been blame for using the cement-stones, dug out of the Hampshire clay in the fort near Browndown, for road-stone, instead of making cement of it, and using burnt clay for the roads.

It may be cheap to buy clay-ground for a railway, because it is not occupied by houses; but it is dear to keep it in order, for both embankments and cut banks of clay require very low angles of rest; they will slip with alternations of drought and wet, and of frost and thaw.

The new forts on clay ground near Sheerness ultimately required reversed arches for their foundations; but these should have been estimated for *at first.*

Clay surfaces slip in two ways—1. By cracks parallel with outcrop, formed in dry weather, and filled with water in wet seasons, until the clay is undermined at their depth, and the sodden mass is allowed to give way in bulk by its own weight over the unsodden clay below. 2. By the whole surface becoming sodden to a certain depth uniformly, and then sliding off the drier and harder clay below, like a heavy wet carpet crumpling and sliding down off a smooth slope.

The relation of clays to landslips and water-supply, valleys and hills, and the military importance of a good road over a clay-district, come under Geological Topography.

§ VII. SLATE.—This is essentially a hardened clay, and is to be looked for in mountains, whilst clay forms low and hollow ground; for slate has resulted from much squeezed argillaceous strata, forced by lateral pressure into complicated and elevated ridge-like folds. When these are coarse-grained they may become schistose, shillety, and shivery; but only when composed of fine-grained mud have they become true *slate*, cleavable in vertical or nearly vertical lines. The schists and slates of mountains "weather" away under ice and water into gullies, gaps, colls, &c.

The many uses to which slate is now-a-days applied need not be enumerated. The coarser slates or schists serve for rough buildings and roofings where nothing better can be had.

§ VIII. Granitic Rocks—Different as they are in appearance, the soft clays and the hard granites are closely related in a lithological point of view. Granite (composed of felspar, quartz, and mica) is often a good building stone; but it is far from being imperishable.

The rain (with carbonic acid) decomposes its felspar, by changing its silicates of potash, soda and lime into soluble carbonates, easily washed away. Hence it is often rotten to great depths, as in Cornwall (Chinastone Quarries), Australia, India, Hong Kong, &c., with unaltered granite blocks remaining in it. This misleads casual observers to think that they see "glacial drifts" where ice has never played a part. Sometimes this local *débris* is consolidated (arkose), as in Australia (Col. T. L. Mitchell). When it is soft, and washed away by snow, rain, and streams, or removed by glacier, the sandy (quartzose) particles and grit, resulting from this disintegration of the granite or gneiss, go to form sandy poor land; the felspar has been mostly removed as clay in the muddy (sometimes milk-white) water. The mica, not quickly decomposed, floats away to distances. If very yellow and thick, its glittering grains may be mistaken for gold.

Granites containing iron-pyrites may look well as building stones at first; but they become stained and broken by the decomposition of the pyrites. Unless labour was wanting in Newfoundland, granite need not have been taken from Aberdeen to build the Government House there! There was no probability of getting a good well of water in the Granite of Canada—to whatever expense the Government might go—not even though the "divining rod" indicated to the Officer in charge the existence of a "spring!" (*auth.* Gen. Portlock.) Granitic and other felspathic rocks, especially those containing hornblende, and little or no mica, are good for road-metal.

§ IX. Coal, Lignite, and Peat.—These and allied substances their characters, conditions, and modes of occurrence, are important to the Practical Geologist. The relative value of these materials much depends on the amount of natural alteration they have been subjected to, and the rock-structures with which they are associated.

§ X. Metallic and other Minerals.—The value of a knowledge of other mineral matters besides those already mentioned might be enlarged upon, for all should be able to discriminate iron-pyrites from copper-pyrites, and both of them and mica from gold; green carbonate and silicate of copper* from chlorite (Namaqualand); manganese ore from iron ore; tin ore from titaniferous iron-sand (Victoria); molybdenite from graphite; galena from lead; stibnite from both, &c. We ought also to have some ability in recognising ores of mercury, cobalt, silver, &c., which are so different from the really valuable metals they yield, and so widely distributed in the traveller's path throughout the world. So also should the tourist be able to decide at once whether he be offered sapphire or blue glass (Ceylon), diamond or rock-crystal (Africa, &c.).

§ XI. Stratal Geology, illustrative of the Structure of Mountains, Hills, Valleys, &c.—Most of the points mentioned above as relative to *materials* are of more use to a resident, whether in town or country, or to a Military Man at a Station, than to a traveller or an Officer on Reconnaissance. The second part of our observations, namely, on the "Structure of Stratified Rocks," is especially important to any one moving about in the open country.

There are many very great differences in the structure of hills, however similar in outline some may appear to be at first sight. With their structure, their real character and conditions correspond; and these must be studied in relation to water-supply, fitness for sites for houses, camps, or strongholds, and with reference also to their scenery, and connection with other parts of the country.

Hills are often *Escarpments*, or the exposed cut edges of inclined or horizontal strata. Along such hill-tops many old lines of road still exist (Ridgways, Reigate, &c.), though now-a-days, the valleys and plains being no longer too marshy and woody for roads, the old ridge-roads are nearly deserted.

Such is the old Pilgrim-road along the North Downs from Hampshire to Canterbury; and its deviation, or rather doubling, at

* An old shepherd in Australia, of course alive to the possible value of green stones in his locality, picked up "a piece of carbonate of copper on the surface, no bigger than a pea." and thus led to the discovery of the Wallaroo Mine, and subsequently of the Moonta Mine, both of which paid three times more dividend than the world-renowned Barra-Barra.

Guildford and Chilworth is due to a geological cause—the presence of two parallel escarpments—each of which was made to offer its own advantages to the Pilgrims by the ecclesiastics of the period. Bunyan's "Slough of Despond," "Hill of Difficulty," "Delectable Hills," and other scenes are to be found along these ranges of hills—a country with which he was well acquainted. (Capt. James, R.E.)

The various modifications in the arrangement of strata forming *Hills* can hardly be understood without illustrative diagrams. Some hills have their contours coincident with the outcrop of their strata, which are then horizontal. Other hills may have synclinal, cycloclinal, anticlinal, or periclinal strata, with very different results as to smoothness of slope, step-edges, water-bearing qualities, relative fertility or barrenness, &c., according to their petrological characters—clays, sandstones, limestones, &c.

In one case, the unregarded anticlinal position of the Chalk of Portsdown Hill * spoilt the hopes of the Engineer boring for water! In another case, a knowledge of an anticlinal arrangement of the strata of Trimpley Hill enabled the late G. E. Roberts to point out how the axial, but unexplored limestone might be got at, and burnt for lime with the coal lying against the foot of the hill. Hills having the same outline may be composed of very differently arranged strata; and, until some evidence of their actual constitution is gathered by a geologist, no one can tell any more of their interior than a child can of pies or dumplings before they are cut open.

Synclinal hills have often been hill-fortresses, both on account of their retaining moisture enough for pasture and for wells, and their presenting precipitous sides. The strongholds of Persian chieftains on the Turko-Persian frontier (Loftus) and Schamyl's last retreat, Gounib in Daghestan (Campbell), are examples. Wenlock Edge, Gibraltar, the Wealden Area, the London and Hants Basins, the Isle of Portland, Killicrankie, the Passes of Kintail, the Matterhorn, and other geographical features of interest are good instances of the enormous variation of character dependent on geological structure.

The relatively good or bad lines for roads, as ruled by strata and petrological conditions, are well understood. The connection

* See Mr. C. Evans' Paper in the "Proceed. Geol. Assoc.," vol. iv., p. 63, and sections.

of one part of the country with another can be known by the exposed edges of hills or cliffs, and the continuation of a hollow, a terrace, a bench, or a ridge can be recognised as a natural, and not as a possibly artificial, feature by the *geological* draughtsman, thus saving much time and trouble.

The recognition of the continuance of strata in exposed surfaces, and of hard veins or dykes of rock along the country, depends upon an acceptance of the principles of Geology. In the "Voyage of the Fox," 1859, p. 269, McClintock says :—"Montreal Island, chiefly grey gneiss, traversed with whitish vertical bands in a N. and S. direction. By these I often directed my route when crossing the island."

So also the reconnoitrer or traveller, seeing the strata on one side of a *flat-bedded* hill, is sure of their existence and probable outcome on the other side; and the intelligent landowner or engineer, knowing the *strike* of a limestone, finds it possible to open out quarries with slight search, and not to have to trust to accidental findings by field-labourers.

§ XII. Water-supply.—The supply of water to towns and camps is of the utmost importance. Geology assists us in forming correct notions as to the best plans for obtaining it; and herein the subject is closely connected with the nature and position of strata. Springs at the surface are not reckless things, occurring anywhere and without a plan. Their origin and supply are governed by rule. Their nature is well understood. Their underground supplies can be made the subject of calculation, and these subterranean waters can be "tapped," by boring and by sinking wells, with greater or less certainty. The vulgar do not know of the extended occurrence of water in the strata beneath; but think that when they find the bottom of a well filling with water, they have by providence or luck struck a "spring."

Without speaking in full of the theory and practice of water-supply, a few facts about springs and wells may be mentioned.

Gravel is the great *superficial water-holder*. The Kurragh, in Kildare, was a great undulating plain of gravel, bordering the valley of the Liffey, with shallow wells sufficient for the inhabitants. It had been encamped upon, but to make a permanent encampment upon it there must be a large water-supply. The Officer entrusted with the formation of the Camp knew little or nothing about the underground water, and judiciously got the best profes-

sional geological advice, acted upon it, and obtained the necessary supply. Although occurring within the last thirty years, this procedure seemed unnecessary and unwarrantable to some old-fashioned Officials among those concerned. Had he known but a little of the Geology of Ireland, however, the Officer in Command could have seen to it himself. (*auth.* Portlock).

The official authorities, in laying out camping-ground at Brown Down, near Portsmouth, were saved, by good geological warning, from putting *drainage* into the *gravel* whence they intended to get the *water*.

Gravel is generally a good water-bearer. Even if a river running in a gravelly valley be turned from a besieged town, the inhabitants may get water by shallow wells, receiving the water still, by infiltration, from the river.

Gravel-bottoms of dry rivers contain water, though not shown at the surface. Travellers know where to look for it there. Elephants on the Orange River of South Africa, and in such like rivers dry for a season, wear down their tusks by making holes and pools in the gravel. For this reason, worn tusks come from dry countries, long tusks from districts where plenty of rain keeps the pools full and vegetation abundant. So the Mammoths of the old world had long full-grown tusks, partly for this reason, and partly because they lived undisturbed by man.

Gravel may be a very bad soil in some places and at some seasons for *Camping*; for the irony "pan," or natural "puddling" at the base of the gravel, keeps it full of water in a wet season; or, if not quite replete with moisture, it is wet to the top by a slight rain. Or it may be a thin mask on clay ground, with similar effects.

Fresh water is to be found often in the shingle and sand of sea-beaches, getting there by infiltration from the truncated edges of the strata of the land, or from the drainage of the land-slopes. Thus, remembering Cæsar's experiences, as given in his Commentaries, Sir Ralph Abercrombie got water for the troops in Marmorice Bay. So, also, General Emmett found fresh water in the beach at Bermuda, for the mortar. Norton's Tube-wells are good for gravel and alluvium, not for solid rocks.

The sand of the Sahara masks the undulating strata of Tertiary and Cretaceous age that stretch away below from the mountain ranges, and carry water from those rain-receiving ridges and

heights. Sometimes broken curves and faults in these strata give out water in springs, making the Oases. The French Engineers have been very successful in tapping the water-carrying strata by borings, thus making many Artesian Springs in the Desert.

One of the most scientifically conducted and successful of wells is that at the Warren Farm, near Brighton. This was persevered in (to a successful termination) in spite of much declamatory opposition. (See Dixon's "Sussex," new Edition.)

Many mistakes have been made, and much money wasted, in well-sinking, for want of geological knowledge. A civilian Engineer, professing to be a special Water-Engineer, once told me of his disappointment and disgust at finding in his borings at three different places, not far from London, what he thought to be a thick, continuous, uniform blue clay, in which he could get no water. He had tried to get water (1) close to London, (2) near Redhill, and (3) near Maidstone. First, he had bored in the bluish London Clay; 2, in the blue Gault; 3, in the purplish Weald Clay. In the 1st he would have had to pierce 400 feet; in the 2nd, about 100 feet; and in the 3rd, 600 feet; and of course failed in each. Knowing nothing of Geology, he mistook these three different clays for one great underlying stratum, reaching from Dan to Beersheba!

§ XIII. Mining.—Mistakes in search for water, in estimating railway-cuttings, and in coal-mining, have often occurred for want of geological precision. On the other hand, one of the most important results of a scientific recognition and study of strata has been the addition of large coalfields in the Midland Counties to the available area of the English Coal-supply. Much of the Coal-measures are covered by "red ground," consisting of either Permian or Permian and New Red Sandstones. The former lying on the coal with a thickness of less than 1,000 feet are easily pierced. The latter, with a thickness of perhaps 3,000 feet, lying on the Permian, make the expense of shafts to the coal too great. All these sandstones make "red ground," uniform in appearance to the uneducated eye. Sometimes, however, dislocations of the strata bring the Permian Sandstones on a level with the New Red, allowing the coal to be easily reached; but, as all these sandstones make "red ground" uniformly over both sides of the dislocation, the ordinary collier or miner could not discriminate which sandstone was the thin cover and which was the thick cover of the coal. The Geological Surveyors learned and pointed out the dis-

tinction, and several long narrow areas of ground that could be economically pierced were mapped along the borders of some of the coalfields.

§ XIV. Topography and Geography.—It is pleasant to travel comfortably, and delightful to see new places and enjoy the pure mountain air and bold scenery; but there is something more than this. There is, or should be, the practicable desire not to go about one's work in life blindfold. He who loiters through a noble library, content with seeing the backs of the volumes in their fine carved cases, admiring even their beauty and their delicate finish, but satisfied with such superficialities, and caring nothing for what lies behind the beauty of the binding, is little removed from the man who admires external and superficial nature, with no care for the greater beauties and greater truths that lie beneath the surface. One may be content to admire, but another may be ardent to know; and thus feeling, he takes the higher standpoint of a seeker after truth, rather than the lower grade of mere animal enjoyment.

Many enquiries are suggested to the thoughtful tourist, "Why the surface of the earth came to be so wonderfully and beautifully diversified; why some mountains are rounded and others precipitous; why some valleys are wide and open, others narrow and rocky; why rivers so often pierce through mountain-chains; why mountain lakes are so enormously deep; whence come the gravel, and drift, and erratic blocks, so strangely spread over wide areas, while totally absent from other areas equally extensive."—A. K. Wallace, "Address on Biology," &c., Brit. Assoc. Meeting, 1876.

Topography is the recognition and description of the general and special natural features of a country, its physical formation, the natural and artificial obstacles to travel, its waterlines, its roads and passes, &c. How many an interesting description of new or little known regions would have been rendered perfect by some definite allusion to the limestone, sandstone, granite, schist, and so forth, seen on the hillsides, passes, or ravines, and constituting the real groundwork, giving rise to the features of the place! In the Proceedings of Geographical Societies, and in other accounts of Voyages and Travels, we read of the slopes and cliffs, flats and peaks, lights and shades, colours and vegetation of the lands explored, but not always of the essential structure on which all these characters depend for their existence.

If we learn that a house presents a mere box-like form, with square holes for windows—or if it be built chiefly of a timber framework, with projecting storeys—or if it possess round or sharp-arched windows and doorways, we learn something of its probable age from its style. But how much better do we realize the description and history of a noted house or of a particular town when we are told if it be mainly built of brick, or of marble, or of sandstone, or of granite; the very roofs, whether of tiles, slates, or tilestones, and the pavements and roadways of flint, flags, limestones, granite, basalt, &c., tell of the nature of the surrounding countries, excepting where easy means of land-and-water-conveyance bring materials from some distance to centres of life and business.

Aberdeen of granite, Bath of oolite, Paris of soft white limestone, London of brick and stucco, Timbuctoo of unbaked mud, Ulundi of wattle—are typical examples of the close connection of structural materials with our recognition and remembrances of towns and places.

The geographist describes *effects*, the geologist gives the *causes* also; and indeed no effects can be understood, not even appreciated fully, without some knowledge of the causes.

An illuminating touch here and there given by geological knowledge vivifies the well-drawn and well-coloured sketch of any scenery of plain, plateau, or mountain; and makes the dumb sketch a living, speaking picture. Ruskin points out Turner's instinctive recognition of geological characters; and we are glad to see frequent expression of such natural features in modern paintings, wherein the several rock-masses plainly bear their own natural characters and features.

Geographers, however, are too often sparing of these touches of nature, these bright illuminative descriptions, or even mention, of exact appearance and properties of the soils and rocks they traverse. A misty veil still hangs between us and the eventful paths they follow, nay, even between themselves and the ground they so laboriously befoot; for one of the essentials in understanding and comprehending the whole is wanting. There is no knowledge of the stony *structure* of regions well worthy of full research, and probably elucidative of other regions, and offering a wonderfully complete composition of old and new, altered and unaltered formations, massed together in a perfect, though apparently confused

order—the result of the work of all the natural forces, through ages and ages, guided by everlasting laws of the Creator. Let us look, for example, at two or three recent descriptions in the Royal Geographical Society's Journal and Magazine. In the Kurram Valley, Afghanistan, "a good deal of marble strewed the beds of the streams at the foot of the mountain [Sikaram], and near the top there was a quantity of loose shale, most disagreeable to climb; but the wind-up [ending] of all consisted of crag-climbing, broken here and there by a sloping bit of snow, which had to be crossed."—*Op. cit.*, Oct., 1879, p. 625.

Is this mountain, with its successive limestones and shales, or marbles and schists, of the Tertiary (Nummulitic), or Palæozoic (Carboniferous), or of some other age?

Take another case in the same part of the Journal, where the geography of a portion of Madagascar is concerned. What little indication of geology is here given helps us much to understand the structure of the country—Plains of flat Neocomian (?) strata [and Tertiary and Post-tertiary, probably] at the margin (reaching a height of 1,000 feet at most), and a broad middle area of "granitic" rocks (5,000 feet high and more), with granite, basalt, and red and brown non-fossiliferous clays. But the "towers, domes, pyramids and spires of rock, and gigantic castles and churches," may be of sandstone, limestone, porphryies, basalt, granite, gneiss, &c.," and their relative age and series are not known.

Compare this with J. Thomas' Geology of Usambara (about 5° S. lat. Africa); *op. cit.*, September, 1879, p. 558, where rather more geological knowledge throws a little more light on the geography.

There is no better guide in the interpretation of what scenery owes to rocks and geological structure, than Archibald Geikie's charming book on the "Scenery of Scotland, as affected by its Geological Structure." We must not forget also, that Prof. A. C. Ramsay's exposition* of the "plane of marine denudation," and

* The operations "in the production of scenery mainly resolve themselves into the following series, the parts of which, ever since land and water first existed, may be arranged in any possible combination:—

"*a.* Oscillation, with respect to the sea-level, of rocks that have or have not been contorted and metamorphosed, accompanied by pauses in oscillation, of greater or less duration.

"*b.* Great plains of marine denudation.

"*c.* Subaërial denudation of all kinds; wearing away of sea-coasts; and in the interior of the country, chemical decompositions, frost, snow, ice,

the resultant mountains, plateaux, and hills, caused by denudation, has afforded a clue to many geographical difficulties—indeed, a ready key to many a maze of circumambient peaks and ridges, puzzling the traveller.

For an intelligible description of a certain hillside, read in the "Water Babies" Charles Kingsley's account of poor little Tom's descent into "Vendale," "over Harthover and down Lewthwaite Crag." (Chapter II.) The "grey crag, grey down, grey stair, grey moor, walled up to heaven," is all the description that a common novelist or tourist would give; but see how Kingsley illustrates and enriches it with his geological knowledge and his botanical notes; for he gives all the real features and characters of an escarpment of the Scar Limestones of the Carboniferous Series, with their interpolated shales and sandstones.

Numerous and excellent as are the explanatory notes on the relation of Geology to Geography in the chapters on the "Form of Ground" throughout the "Memoirs of the Geological Survey of Great Britain and Ireland," many as are similar observations in the writings of all standard geologists, and in special works, such as Geikie's highly valued "Scenery of Scotland," yet few strike me as more apt and forcible than several passages in the late Prof. James Nicol's "Geography and Scenery of the North of Scotland," 1866 (page 7, &c.).

What can an educated Traveller or an accomplished Staff-Officer do with geological knowledge in a scientific journey or in a military reconnaissance? He can see further than a mere surveyor! He can see more than the outline of hill and vale, or of gorge and peak! He can see which of the hillsides is sandrock or limestone, or granite, with all their certain or probable properties or conditions. He can see where a valley has its floor of porous gravel, or of light loam, or of stiff clay, or of black peat! What is more, he can appreciate their relative value, or their relative evils, to him and to others! He traces the run of clay-bands, or of hard rock, along or across the country! He can tell what is on the other side of some hills he looks at, nay—even what he may expect to find on the other side of a mountain-range! He sees the rolling and pitching of strata to right and left, from hill to hill; and he

wind, rain, and rivers; modified by height of land, and the various positions, hardness, and other characters of rocks."—A. C. Ramsay, "Phil Mag.," 1864, Vol. xxviii., p. 298.

knows what further strata they bear on their broad backs, east or west, north or south. The escarped side of a hill will tell him whether the background is a plateau, flat or sloping, good for roads, or made up of rifted rocks, and crumpled strata, impassable! He knows whether yonder ridge, dividing the valleys, continues the dry sand-rock, the grassy limestone, or the barren granite of the neighbouring mountains! He knows *reasonably* a volcanic cone, a trappean knoll, a basaltic cliff, also their possibilities and values. He will not set compass on such a rock, for he would lose his direction; he would not lay telegraph wires on them, for his electric slave would rebel at their touch! He can tell where water lies in the synclinal or the faulted strata, for his indication is the knowledge of observation, not the ignorance of the "dowsing fork," or "divining rod," for which, indeed, the Australian savage, watching the gnats dancing over a water-spot, ought to have a supreme contempt.

He knows whether the strata in a plain slope from the mountain or towards it, and therefore how the water soaks and runs beneath. As a General of genius, or the educated Soldier, "has an eye for a country," for positions and manœuvres, so the Geologist has an eye for the capabilities of a country. The earth is open to his educated eye, just as a diagram may show surface and section. Further, he can enjoy the varied tints of morn and eve, and sketch with pleasure the lights and shadows of Nature's architecture, as well as those who know only the outside; whereas his knowledge of the *structure* adds pleasure to his enjoyment, gives distinctness to his touch, and renders his description of each part, high or low, rough or smooth, definite and to the purpose.

Henry I. bought his own knowledge of the Wenlock Edge; and, having, perforce, sacrificed his men in his first passage of those hills, he made a good open road for his return; and it lasts to this day. The Great Duke consulted the best maps he could get, and studied nature with his almost intuitive knowledge, when he disregarded the Govermental Orders to attempt the Tagus in 1818; and, disembarking at the best landing place (mouth of the Mendego) to be found in Portugal, entered on his victorious campaign.

Sir John Moore's forces landed at Maciera Bay in the face of natural difficulties (but in accordance with Government Orders), and suffered great loss.

The unhappy Junot, in his march on Lisbon, was in bad case

—no topographical knowledge, no forethought, all ruin—for want of geographical and geological aids. From Bayonne to Burgos, to Valladolid, to Salamanca, the French had weary marches through broad valleys, traversed by the branches of the Ebro and Douro; and then 120 miles across the barren foodless Sierra de Guadarama, with its southern precipices. Out of 23,000 men mustered at Alcantara, only 15,000 remained. The rest of his march was equally badly chosen. His Staff did not help him. He reached the city with only 1,500 men.

The great influence that wet and dry soils, respectively, have on health is not only an every-day subject of talk, but has been scientifically treated by W. Whitaker and others; and it is one of the recognised subjects in the education of Sanitary Engineers.

How often do we hear of careful choice of a gravelly soil for the foundation of a house; yet, even when found and obtained, it may prove deceptive and a failure, for the want of complete application of geological knowledge; thus, the house may be on the edge of a gravel bed just in the way of the water discharging from the gravel; and thus it may have one wall always wet, or its cellar flooded now and then, or some other inconvenience.

The effects of topography on health, growth, and character even, are well seen in fenlands especially. The marshy district of Lambeth is said to change poor immigrants in course of time to less lively and cheerful-looking persons than they were in even the East of London or elsewhere.

One set of causes reducing the activity of fen-dwellers may be that *water* is *easy* to be fetched; *land* is *easy* to be dug; *fuel* (peat) is *easy* to be got; *crops* (such as they are) are *easy* to be raised. Thus these flat and fat marshlands do not give rise to any great exertion of strength and energy such as are brought out by the hard weather and hard life on uplands among mountaineers. We must except, however, such people as the Dutch, who fortifying Holland against the waters, and fighting persistently against the physical conditions of the sea, receive and perpetuate the same constitutional results as are produced by other nations holding continual fight against the physical conditions of the Alps. Both kinds of life require seriousness, earnestness, and indomitable courage; and these qualities have characterised the inhabitants of Holland and their political life, as much as they are native to the Swiss among the snows and precipices of their mountains.

The sites of battle-fields, the lines of ancient roads, the elucidation of history by explanation of changes of coasts and river-bends, are all to be worked out with reference to Geology; and much interesting work has been done in this direction.

The races of India have been conquered by the British, and to a great extent her rocks and soils were conquered by amateur Geologists of the British Army. Before the Geological Survey of India was instituted about thirty Officers and twelve Army Surgeons had communicated valuable observations on India to the Geological Society of London.

Sir C. Napier assigning a baggage-camel for Capt. Vicary's Geological specimens in Beloochistan ("Quart. Journ. Geol. Soc.," Vol. ii., p. 260) showed that he would not regard the nation fully conquered until a geological knowledge of their land was also won. Capt. Newbold reduced large portions of India, Syria, and Egypt in subjection to Geology. Capt. Nelson, R.E., brought the Bahamas and Bermuda to the knowledge of geologists. Admiral Spratt, C.B., R.N., has gaven us much geological knowledge of many parts of Greece and Turkey.

Captain Robert Jones Garden was aided in excavating the large Cretaceous Ammonites from the Natal Cliffs by a determined and willing soldier,* who fell a victim to his exertions there (by dysentery).

Dr. Bow almost fell captive to the Khyberees when his horse fell with him on a bold dash after fossils for his friend Capt. Vicary, in one of the Afghanistan expeditions. "Quart. Journ. Geol. Soc.," Vol. vii, p. 44.

The Arctic Voyagers, from the time of Parry to late years, have always taken special care to bring home descriptions and specimens from the frozen lands for Geologists. Excepting where the weight of specimens even has not been grudged in the heavily laden sledges dragged along by the almost exhausted strength of toil-worn, scurvy-bitten survivors of once hearty parties, I know no more enthusiastic search for and securing of fossils than in the case of the sailor (Manson) who brought away a fossil from the high latitude at Seal Island, carefully wrapping it in a piece of his own shirt (Salter's "Appendix to Capt. Penny's Voyage," &c.). At all events this illustrates the enthusiasm with which Geology may be followed under circumstances of discomfort and difficulties.

* Thomas Souton; "Quart. Journ. Geol. Soc.," Vol. vii, p. 453.

§ XV.—Geological Household Words.—That special Geology is of use we know; that every good geological fact, well recorded, will be of use, there is no doubt; and *Knowledge* in this instance, as in others, is *Power;* just as Ignorance is weakness and disgrace. How to find Stone, Clay, and Water for a settlement—good camping ground, fuel, and water for an army—how to manage draining, earthworks, and other operations connected with the surface of the ground—how to choose road-ways, lines for canals, passes in mountains, fords in rivers—these are all aided by Geology, and how to avoid errors and mis-management. But there is another source of utility and gratification in Geology, that is in its providing most desirable means of amusement in the fields and of getting rid of *ennui* in the camp and barracks, in the shifting tent, and the lonely hut. That men take to it naturally everyone knows. We pick up curiosities from the stone-heap, we wonder at the strata in hills and valley-sides, we ask questions, we write letters in newspapers about what we do and what we don't know as to the world and its inside. Geological words have in some cases become household words. In common conversation and in literature we meet continually with allusions to, and similes based on, the physical aspects of the ground as "the ups and downs of life's journey," "the rugged path of life," "the flowery banks of pleasure," "the deep waters of affliction," "as firm and fixed as the everlasting hills" (which is a misnomer, as every shower of rain may prove); so also lithology is made to supply words of more or less meaning—such as the "flinty heart," "as hard as adamant," "diamond cut diamond;" and Geology supplies, in its turn (as people become more and more acquainted with it, or with its literature), some useful terms, allegorical or otherwise, as "the upper (or lowest) stratum of society," "volcanic outbursts of revolution," and so forth. The latest such application of a geological term in current literature is where the *Economist* of October 4, 1879, states that some principle or procedure "Is accepted by general consent as the bottom or hard pan,* from which to take a new departure, and on which to build a future prosperity."

§ XVI.—Conclusion.—The old Scotch Inn-wife, in Walter Scott's "St. Ronan's Well" (Chapter 2), says "Some rin up hill

* Iron-rust accumulated by percolating rain-water at the bottom of gravel cements it into a hard layer. Still more lately the "Times" of April 14, 1880, writes:—"Great majorities, at least on the Liberal side, always present, so to speak, *lines of cleavage.*"

and down dale, knapping the chucky stanes to pieces wi' hammers, like sae mony road-makers run daft. They say it is to see how the warld was made." Whatever that strong-minded old woman thought of the doings of the idlers at New Saint Ronan's, they might have done much worse than geologizing; and indeed the faithful chronicle of the doings of the fashionable and feckless company there tells us as much! The wholesome exercise of body and mind in walking and observing, noting, reading, and forming careful conclusions, called for in Geology, is not the least of its many uses and advantages. Our Association has been constituted with the view of making the most of such results in both individual and mutual study of the science. It has certainly been successful hitherto; and wide regions are still open for research, with their easy flats and wearisome prairies, their hills of difficulty, and crested mountains, the passes of which are not yet found. The meaning and causes of all and everything in and about them have also to be carefully studied, or we are not true to our duty as Men, and our calling as Geologists.

One of the best and surest rewards for our labour will be with us always in all our true work, making us better than we have been, for "Whatever withdraws us from the dominion of the Senses—whatever makes the Past, the Distant, and the Future predominate over the Present, advances us in the dignity of Thinking Beings." (Dr. S. Johnson, "Tour to the Hebrides.")

ORDINARY MEETING.

DECEMBER 5th, 1879.

WILLIAM CARRUTHERS, Esq., F.R.S., Vice-President, in the chair.

The Donations received since the previous meeting were announced, and the Donors received the thanks of the Association.

The following were elected Members of the Association:—

Alfred H. Blake, Esq.; J. W. Davis, Esq., F.G.S.; J. Faulkner, Esq.; George J. Hinde, Esq., F.G.S.; R. W. Hinton, Esq., B.A.; G. H. Morton, Esq., F.G.S.; and Augustus W. Webb, Esq.

The following Paper was read:

ON THE IGNEOUS ROCKS OF ARTHUR'S SEAT.

By ANDREW TAYLOR, Esq.

The Insect Fauna of the Primary or Palæozoic Period, and the British and Foreign Formations of that Period in which Insect Remains have been Detected.

By Herbert Goss, F.L.S., F.G.S., &c.

(*Read 7th March*, 1879.)

Introduction.

In the Palæozoic rocks of the United Kingdom remains of insects appear to be extremely rare, and the few fragments which have been discovered have all been obtained from the Coal Measures. On the Continents of Europe and America fossil insects have been found more frequently in Palæozoic rocks; but with the exception of the remains of a few specimens from the Permian of Europe, and the Devonian of New Brunswick, North America, all the specimens have been discovered in the Carboniferous rocks.

From the Permian rocks only thirteen fossil insects are known, all of which have been discovered in Saxony. Two of these, from their possessing characters common to two Orders, have been placed by Dr. Goldenberg in an extinct Order, which he has called *Palæodictyoptera*.[1] Two others have been referred to the *Hemiptera*, and the remaining nine to the *Orthoptera*.

From the Carboniferous rocks about 103[2] species of insects have been described. Of these 5 were obtained from the United Kingdom,[3] about 66 from the Continent[4] of Europe, and 32[5] from North America.[6]

[1] See "Fauna Saræpontana Fossilis," Heft 2, 1877.

[2] Inclusive of 10 species of Cockroaches, which have been described by Mr. Scudder since this paper was read in March, 1879.

[3] Coalbrook Dale, Shropshire; near Sunderland; near Glasgow, &c.

[4] Saarbrück, in the Rhenish Provinces of Prussia; Brücken Waldmohr, Rhenish Bavaria; Manebach, in Saxe Weimar; Wettin and Lobejün, in Prussian Saxony; Klein-Opitz, near Dresden; Erbignon, Valais, Switzerland; Sars-Longchamps, Mons, and elsewhere in the Belgian Coalfields; Commentry (Allier), France, &c.

[5] Inclusive of the 10 species recently described by Mr. Scudder as abovementioned.

[6] Sydney, Cape Breton; Picton, Nova Scotia; Cannelton, Beaver County, and Pittston, Pennsylvania; Cassville, Western Virginia; Bellaire and Talmadge, Ohio; Morris, Danville and Colchester, Illinois; Frog Bayou, Arkansas, &c.

In the Coal Measures remains of the *Neuroptera* (or *Pseudo-Neuroptera*) are comparatively numerous, and in addition to some eleven species, which, (from their possessing characters common both to that Order and the *Orthoptera*,) have been placed by Dr. Goldenberg in the extinct Order[1] before-mentioned, about twenty-four species have been determined.

The *Orthoptera* of this age are represented by more than sixty[2] species, and this Order and the *Neuroptera*—if we include in the last-named those species which have been referred by Goldenberg to the extinct Order *Palæodictyoptera*—comprise all the insects yet discovered from the Carboniferous rocks, except five, two of which have been referred to the *Coleoptera*,[3] and three to the *Hemiptera*.[4] Had the two last-named Orders been thoroughly established, and widely distributed at this Period, their remains would doubtless have been discovered, at least as frequently as those of the *Neuroptera* and *Orthoptera*. It may be inferred, therefore, that at this period the *Neuroptera* and the *Orthoptera* were the dominant Orders, and that towards its close the *Hemiptera* and *Coleoptera* began to make their appearance.

From the Upper Devonian rocks of St. John's, New Brunswick, six species of insects have been discovered, all of which have been described by Mr. Scudder, and referred by him to the *Neuroptera*, or *Pseudo-Neuroptera*. These Devonian rocks of New Brunswick are, according to present discoveries, the oldest in the world in which any traces of insects have been detected.

Before proceeding to enumerate the fossil insects obtained from the Palæozoic rocks, I will briefly allude to those Geologists and Zoologists to whom we are chiefly indebted for their discovery, determination, or description.

Amongst the names of the authorities on the fossil *Arthropoda* from the Palæozoic rocks of the United Kingdom, the most

[1] *i.e.*, *Palæodictyoptera*. See "Fauna Saræpontana Fossilis," p. 50 (1877).

[2] Inclusive of those recently described by Mr. Scudder as before mentioned.

[3] *Curculioides Ansticii* and *Troxites Germari*.

[4] *Fulgorina Ebersi*, *F. Klieveri*, and *M. Hollebeni*.

prominent is that of Dr. Henry Woodward, F.R.S.[1]; and in connection with the description or determination of the fossil insects of this period, I must also mention the names of Sir Roderick Murchison, F.R.S.,[2] Dr. Mantell, F.R.S.,[3] Dr. Buckland, F.R.S.,[4] Mr. Robert McLachlan, F.R.S.,[5] Mr. J. W. Kirkby,[6] Mr. A. H. Swinton,[7] Mr. J. W. Salter,[8] and Mr. Curtis.

Amongst the Continental authorities on Palæozoic *Insecta* are Dr. Goldenberg,[9] Prof. Germar,[10] Prof. Oswald Heer,[11] Dr. Giebel,[12] Dr. Anton Dohrn,[13] Herr Mahr,[14] Dr. Jordan,

[1] See Dr. Woodward's papers in the "Geol. Magazine," Vol. viii., p. 385, 1871; Vol. ix., 1872; Vol. x. (No. 3), 1873; "Transactions of the Geol. Soc.," Glasgow, Vol. ii., pt. 3, 1867; "The Quarterly Journal of the Geol. Soc.," February, 1876, &c., &c.

[2] "The Silurian System" (pt. 1), pp. 104-105, 1839.

[3] "The Medals of Creation," Vol. ii., p. 552, 1854.

[4] "Bridgewater Treatise," Vol. i., pp. 409-410; and Vol. ii., pp. 75-76, 1836.

[5] See "Compte-Rendu" of the Soc. Ent. Belge., August, 1877; and see "Nature" (No. 496), Vol. xx., pp. 5-6, May, 1879.

[6] "Geol Magazine," Vol. iv. (No. 39), pp. 388-390, September, 1867.

[7] "Geol. Magazine," Vol. i. (Decade 2), p. 337, 1874.

[8] "Quarterly Journal Geol. Soc." Vol. xix., 1863.

[9] "Sitzungsb. math. nat. Cl. k. Akad. Wiss.," Wien, Bd. ix., pp. 38-39, Wien, 1852; "Ueber versteinerte Insektenreste im Steinkohlengebirge von Saarbrücken," Amtl. Ber. Vers. Gesellsch. deutsch. Naturf., xxix., pp. 123-26, Wiesbaden, 1853; "Die fossilen Insecten des Kohlenformation von Saarbrücken," in "Palæontographica," Vol. iv., 17-40, 1854; "Beiträge zur vorweltlichen Fauna des Steinkohlengebirges zu Saarbrücken," in the "Jahresbuch. k. Gymn. u. Vorsch. Saarbrück.," pp. 1-26, 1867; "Neues Jahrbuch für Miner," pp. 158-168, 1869; "Neues Jahrb. für Miner," pp. 286-289, 1870; "Fauna Saræpontana Fossilis," "Die fossilen Thiere aus der Steinkohlenformation von Saarbrücken," Heft 1, 1873, and Heft 2, 1877.

[10] "Beschreibung einiger neuen fossilen Insecten," II. "In Schieferthon des Steinkonlengebirges von Wettin," see Münster's "Beiträge zur Petrefactenkunde," Heft 5, 1842; "Die Versteinerungen des Steinkohlengebirges von Wettin und Lobejün in Saalkreise," Halle 1844-'853.

[11] "Ueber die fossile Kakerlaken," "Vierteljahrschrift d. Naturf. Gesellsch. in Zurich," Vol. ix., 1864; "Die Urwelt der Schweiz," Zurich, 1865; "Le Monde primitive de la Suisse" (French translation by M. Demole), Geneva and Basle, 1872; and "The Primæval World of Switzerland" (English translation by W. S. Dallas, edited by J. Heywood), London, 1876; "Die Urwelt der Schweiz" (2nd edit.), Zurich, 1879.

[12] "Fauna der Vorwelt mit steter Berücksichtigung der lebenden Insecten und Spinnen" (Insecten und Spinnen), Vol. ii., Leipsic, 1856.

[13] "Palæontographica," Vol. xiii., p. 333, 1866; and *op. cit.*, Vol. xvi., p. 129, 1869.

[14] "Neues Jahrbuch für Mineralogie," p. 282, 1870.

Herr Eugen Geinitz,[1] Dr. Hagen,[2] Dr. H. B. Geinitz,[3] Prof. Pictet,[4] Dr. Fric, Prof. Van Beneden,[5] M. Coemans, M. Audouin,[6] M. Alfred Preudhomme de Borre,[7] and M. Charles Brongniart.[8]

For our knowledge of the fossil insects of the Palæozoic rocks of North America we are indebted chiefly to Mr. Scudder,[9] and also to Dr. Dawson,[10] Professor Dana,[11] Professor Leo Lesquereux,[12] Mr. Harger, Mr. C. F. Hartt, Mr. F. B. Meek, Mr. A. H. Worthen, Dr. Newberry, Mr. James Barnes, Mr. J. G. Bronson, Mr. R. D. Lacoe, Mr. R. Brown, and Mr. J. F. Mansfield.

I will now proceed to enumerate the fossil insects which have been described from the Primary rocks. After having done this, I shall briefly review the facts which have been brought under notice in this and the two preceding papers, and shall endeavour to suggest a few deductions which may be drawn therefrom.

1 "Neues Jahrbuch für Min.," pp. 691-704, 1873; "Neues Jahrbuch für Min.," pp. 1-14, 1875.

2 "Linnaea Entomologica," Zeitschrift von dem Entomologischen Vereine in Stettin," Band 10, p. 302, 1855.

3 "Sitzungsb. naturw. Gesellsch. Isis," pp. 7-13, Dresden, 1879.

4 "Traité élementaire de Paléontologie," Geneva, 1846, and Paris, 1854.

5 "Bull. Acad. Royale de Belgique," 2me Serie, T. xxiii., No. 4, 1867.

6 "Ann. Soc. Ent. France," Vol. ii., Bull., pp. 7-8, 1833.

7 "Notes sur des empreintes d'insectes fossiles," "Ann. Soc. Ent. Belgique," T. xviii., 1875.

8 "Ann. Soc. Ent. France," vme Serie, 1876; "Comptes-Rendu Soc. Ent. Belge," pp. 9-12, January, 1878; and "Ann. des Sciences Naturelles," 6me Serie, Tome 7 Art. No. 4, 1879.

9 See Dawson's "Acadian Geology," 2nd edit., p. 388, London, 1868; "The Geological Survey of Illinois" (Worthen), Vol. iii., pp. 566-572, 1868; "Canadian Naturalist ' (N.S.), Vol. vii., pp. 271-272, Montreal, 1874; "Proc. Amer. Assoc. adv. Science," Vol. xxiv., pp. 110-111, Salem, 1876; "Canad. Nat." (N.S.), Vol. viii., pp. 88-90, Montreal, 1876; "Geol. Mag." (N.S.), Vol. iii., pp. 519-520, London, 1876; "Proc. Bost. Soc. Nat. Hist.," Vol. xix., pp. 238-239, Boston, 1878; "The Early Types of Insects," Bost. Soc. Nat. Hist., Vol. iii. Part 1, No. 2, Boston, March, 1879; "Palæozoic Cockroaches," Memoirs of the Bost. Soc. Nat. Hist, Vol. iii., pt. 1, No. 3, pp. 23-134, Boston, November, 1879.

10 "Quart. Journal Geol. Soc., Lond.," Vol. xvi., p. 268; "Geol. Mag.," Vol. iv., No. 9, 1867; and "Acadian Geology," 1868.

11 "Sill. Journ." (2), Vol. xxxvii., pp. 34-35, 1864.

12 Owen's 2nd "Report Geol. Arkansas," pp. 295-399, 1860.

GREAT BRITAIN.

CARBONIFEROUS.

Of the five fossil insects obtained from the British Coal-measures, four have been referred to the *Orthoptera*, and one to the *Coleoptera*. The representative of the last-named order is the oldest British fossil insect known. It was discovered in the Iron-stone of Coalbrook Dale, Shropshire, and was described by Dr. Buckland[1] as *Curculioides Ansticii*.[2]

The first discovered species of *Orthoptera* from the British Carboniferous rocks was also obtained from the Ironstone of Coalbrook Dale. Sir Roderick Murchison[3] observes of this fossil:—"It was supposed to be a plant, and was sent to Adolphe Brongniart, who immediately perceived that the transverse nervures were unlike anything in the vegetable kingdom, and on being referred to M. Audouin, it was pronounced to be the wing of a *Neuropterous* insect, resembling the living *Corydalis* of Carolina and Pennsylvania." It was subsequently described by Dr. Mantell[4] as belonging to the genus *Corydalis* of the *Neuroptera*, and was named by him *Corydalis Brongniarti*. Mr. Swinton has since referred this insect to the genus *Gryllacris* of the *Orthoptera*.[5]

In addition to these fossils, three fragments of *Orthoptera* were discovered, some years ago, in the Durham Coal-fields.[6] One of the fragments is described by Mr. Kirkby as being a very fine distinct example of the anterior portion of the fore wing of an insect, in form and neuration agreeing with the genus *Blatta*, but

[1] "Bridgewater Treatise," Vol. ii., *antea cit.*, p. 76; see also the "Geol. Trans." (2nd series), Vol. v., pt. 3, p. 446; and "The Silurian System," *antea cit.*, pp. 104–105.

[2] Dr. Buckland describes two insects from Coalbrook Dale as *Curculionidæ*, *i.e.*, *C. Ansticii* (above-mentioned) and *C. Prestvicii*; but Dr. H. Woodward, has decided that the last-named fossil should have been referred to the *Arachnida* and not to the *Insecta*. See "Geol. Mag.," Vol. viii., p. 385, September, 1871.

[3] "The Silurian System" (pt. 1), *antea cit.*, pp. 104-105.

[4] "Medals of Creation," Vol. ii., p. 552, 1854.

[5] See a paper by Mr. A. H. Swinton in "Geol. Mag.," p. 337, pl. xiv., August, 1874.

[6] The locality was the North bank of the Wear, opposite to Claxheux, about two miles west of Sunderland. See Mr. Kirkby's paper in the "Geol Mag.," Vol. iv., p. 388, 1867.

approaching the *Mantidæ*.[1] The third[2] specimen is believed, from its shape and neuration, to be the abortive anterior wing of some species belonging to the *Phasmidæ*, but it is impossible to pronounce with any certainty as to its probable affinities.

The most recently discovered fossil insect from British strata of this period was found in a clay-ironstone nodule obtained from the Scottish Coal-fields. It has been referred[3] by Dr. Henry Woodward to the *Mantidæ*, and has been named by him *Lithomantis carbonarius*.

CONTINENT OF EUROPE.

PERMIAN.

The Permian rocks are extensively developed in Russia and Germany, and they also occur in some parts of Great Britain and North America; but from their comparatively limited geographical and superficial range, the number of fossils obtained from them is proportionately small, and of the *Insecta* only about thirteen species have been discovered, all of which were found in that part of Germany[4] which has been styled by Lyell[5] "the classic ground" of this formation on the Continent.

One of the first discovered and most interesting of these insects, was obtained from an Ironstone pit, belonging to Herr Böcking, at Schwarzenbach in the district of Birkenfeld, and was described in 1866 by Dr. Anton Dohrn,[6] who named it *Eugereon Böckingi*.[7] Dr. Dohrn states that Herr Tischbein and Dr. Hagen

[1] Dr. Goldenberg has included this insect in his list of fossil *Blattidæ*, under the name of *Blattidium mantidioides*. (See "Fauna Sar. Fossilis," pt. 2, p. 20, 1877).

[2] The second specimen appears to be a part of the same insect as No. 1.

[3] "Quart. Journal Geol. Soc.," February, 1876, p. 60. In deciding as to the family to which this fossil belonged, Dr. Woodward states that he had the advantage of the opinions of Mr. Mc Lachlan, Prof. Westwood, and Mr. C. O. Waterhouse.

[4] Schwarzenbach, near Birkenfeld Cassel, and Weissig, near Pillnitz, in Saxony.

[5] "Elements of Geology," 6 edit., p. 460.

[6] "Palæontographica," Vol. xiii., p. 333, 1866.

[7] For a description of this fossil, see "Palæontographica," last *cit.*; and also Vol. xvi., p. 129, 1869; the "Stettiner Ent. Zeitung," xxviii., 1867; and Goldenberg's "Fauna," pt. 2, *antea cit.*, pp. 11-14, 1877.

both regarded this insect as an *Hemipteron*, and he adds that he was originally of the same opinion himself, but that after a further examination of this remarkable fossil, he decided that it could not be referred to any existing Order, as it combined characters both of the *Neuroptera* [1] and *Hemiptera*.

Dr. Dohrn does not, of course, regard *Eugereon* as a type of the common ancestor or progenitor of the *Neuroptera* and *Hemiptera*, as both these Orders were already in existence; but he is of opinion, that at a very remote period a form existed, completely intermediate between these two Orders, from which they were differentiated, and from which *Eugereon* was also descended.

As this insect could not be referred to any existing Order, it was placed by its describer in a new Order, which he created for it, and which he named *Dictyoptera*; it has recently been included by Dr. Goldenberg [2] in his Order *Palæodictyoptera*.

Another fossil, scarcely less interesting than *Eugereon*, discovered by Herr Karl Rückert in the neighbourhood of Stockheim, in Bavaria, was described in 1865 by Dr. H. B. Geinitz,[3] who named it *Ephemerites Rückerti*. From its union of characters of the genera *Ephemera* and *Libellula*, Dr. Goldenberg has recently placed this fossil in his Order *Palæodictyoptera*.

A fragment of a wing, obtained from Weissig, near Pillnitz, in Saxony, has been referred by Herr Eugen Geinitz [4] to a species of *Hemiptera*—*Fulgorina Klieveri*—a specimen of which has been also obtained [5] from the European Coal Measures; but Dr. Goldenberg has recently informed [6] me that he is not aware of any specimen of the last-named species (*F. Klieveri*) having been discovered in Permian strata; but that two other species belonging to the genus *Fulgorina*, viz., *F. Ebersi* and *F. lebachensis*, have been obtained from the Permian.

The nine other insects discovered in strata of this age all belong

[1] All the synthetic types hereinafter alluded to exhibit a union of the characters of *Neuroptera* and *Orthoptera*, or *Neuroptera* and *Pseudo-Neuroptera*.

[2] "Fauna Sar. Foss.," pt. 2 (1877), *antea cit.*, p. 50.

[3] "Neues Jahrb. für Min.," pp. 385-388, 1865.

[4] See "Neues Jahrb. für Min.," pp. 6 and 12, and plate 1, fig. 3, p. 112, 1875.

[5] Described by Dr. Goldenberg in "Neues Jahrb. für Min.," p. 166, 1869.

[6] In a letter dated 12th January, 1879.

to the extinct genus *Blattina*[1] of the family *Blattidæ* of the *Orthoptera*, and the majority of them were obtained from Weissig. Of these *Blattidæ*, five species—*Blattina Weissigensis*,[2] *B. porrecta*,[3] *B. Rückerti*, *B. lebachensis*, and *B. gracilis*—have only been discovered in Permian strata, but specimens of the remaining four, viz., *B. didyma* (*sopita*), *B. anthracophila* (*flabellata*), *B. carbonaria*, and *B. Mahri* (*elongata*) have been also obtained from the European Coal Measures.

The specimen of *Blattina didyma*[4] (*sopita*) from the Permian appears, for an insect of such vast antiquity, to be in an unusually perfect state of preservation, the body, wings, and legs being almost entire; but the other *Blattidæ* are represented only by single wings, or parts of wings.

CARBONIFEROUS.

The principal localities on the Continent of Europe in which fossil insects have been discovered in the Carboniferous rocks, are Saarbrück, in the Rhenish provinces of Prussia; Brücken, Waldmohr, Rhenish Bavaria; Manebach, in Saxe Weimar; Wettin and Löbejün, in Prussian Saxony; Klein-Opitz, near Dresden; Erbignon Valais, Switzerland; Sars-Longchamps, and Mons. Belgium; and Commentry (Allier), France.

Of *Neuropteroid* insects about sixteen species have been obtained from the neighbourhood of Saarbrück, nine[5] of which have been referred by Dr. Goldenberg[6] to an extinct genus—*Dictyoneura*—and have recently been placed by him in the extinct Order *Palæodictyoptera*. The remaining seven species are representatives of the family *Termitidæ*, viz., *Termes Heeri*, *T. affinis*, *T. Hageni*, *T. Buchi*, *T. laxa*, *Termitidium amissum*, and *rugosum*.

About fourteen years ago M. Coemans discovered at Sars-Longchamps, in the Belgian Coal-fields, the wing of an insect in a

[1] Mr. Scudder has recently distributed these Permian *Blattidæ* amongst his new genera—*Etoblattina*, *Anthracoblattina*, *Hermatoblattina*, and *Petrablattina*.

[2] Described by Herr Eugen Geinitz, in "Neues Jahrb. für Min.," pp. 692-694, 1873.

[3] Eug. Geinitz in "N. Jahrb. für Min.," p. 6, 1875.

[4] See "N. Jahrb. für Min.," 1875, *antea cit.*, plate 1, fig. 1, p. 112.

[5] *Dictyoneura libelluloides*, *anthracophila*, *formosa*, *Decheni*, *elegans*, *elongata*, *Schmitzii*, *obsoleta*, and *Humboldtiana*.

[6] "Fauna Saræpontana Fossilis," *antea cit.*, 1873 and 1877. See also "Palæontographica," Vol. iv., 1854.

tolerably perfect state of preservation, which was referred by him and Prof. Van Beneden to an extinct genus of *Neuroptera*. This fossil was subsequently described[1] by them as *Omalia macroptera*, and it has since been included by Dr. Goldenberg[2] in his Order *Palæodictyoptera*.

In 1874 three specimens, or rather fragments, of insects were discovered by M. Persinaire and M. Crepin, in the Mons basin of the Belgium Coal-fields, and were subsequently described by M. Alfred Preudhomme de Borre.[3] One of the fragments was *supposed* to be part of the wing of a species of *Termes*, but it was in far too imperfect a state to admit of its determination.

The most perfectly preserved wing of the three[4] was originally described by M. de Borre as belonging to the *Orthoptera*, and was named by him *Pachytylopsis Borinensis*[5]; but after Dr. Breyer had examined it, and expressed an opinion that it belonged to the *Lepidoptera*, its name was changed to *Breyeria Borinensis*. This fossil was subsequently submitted to Mr. McLachlan,[6] in Brussels, in August, 1877, and he decided, after a careful examination of the wing, in which he detected abundant traces of transversal reticulation, that it could not have belonged to the *Lepidoptera*,[7] and that it was the wing of a *Neuropterous* insect of the family *Ephemeridæ*.

The fossil *Orthoptera* from the European Coal Measures belong, with few exceptions, to the *Blattidæ*, of which family about thirty-six species have been described by Germar, Goldenberg, Giebel, Heer, H. B. Geinitz, E. Geinitz, Dohrn, and Mahr, viz., *Blattina primæva*,[8] *labachensis*, *insignis*, *winteriana*, *intermedia*, *scaberata*,

[1] "Bull. Acad. Royale Belgique," 2nd Series, Tome xxiii., pp. 384-401, 1867.

[2] "Fauna Sar. Fos.," Heft 2, *antea cit.*, 1877.

[3] "Notes sur des empreintes d'insectes fossiles." "Ann. Soc. Ent. Belgique," Tome xviii., 1875.

[4] For the name of the second specimen belonging to the family *Acridiidæ* of the *Orthoptera*, see next page.

[5] "Bull. Acad. Royale Belgique," *antea cit.*

[6] "Compte-Rendu Soc. Ent. Belgique," August, 1877, *antea cit.*; and "Nature" (No. 496), Vol. xx., pp. 5-6, May, 1879.

[7] Mr. Alfred Russel Wallace believes the wing to be *Lepidopterous*. See "Nature" (No. 495), Vol. xix., p. 582, April, 1879.

[8] Since this paper was read in March, 1879, Mr. Scudder has re-described all the known species of fossil cockroaches from Europe and America in a very long and elaborate paper, published in the "Memoirs of the Boston Society of Natural History" (Vol. iii., pt. 1, No. 3, *antea cit.*). With the exceptions of *Tischbeini*, *latinervis*, and *granosus*, the two first of which are still referred to the genus *Blattina*, and the last named to the genus *Poly-*

wemmetsweileriensis, *Tischbeini*, and *Polyzosterites granosus* from the neighbourhood of Saarbrück; *B. Remigii* and *weissiana*, from Cusel and Brücken respectively; *B. didyma*, *Manebachensis*, *Goldenbergi*, *latinervis*, *clathrata*, *Mahri*, and *Fritschii*, from Manebach; *B. euglyptica*, *affinis*, *flabellata*, *anthracophila*, *Dohrnii*, *anaglyptica*, *carbonaria*, *russoma*, *leptophlebica*, *parvula*, *spectabilis*, *Geinitzi*, *Münsteri*, *producta*, *Germari*, and *reticulata*, from Wettin and Löbejün; *B. Dresdensis*, from Klein-Opitz, near Dresden; and *B. Helvetica*, from Erbignon Valais, which according to Professor Heer [1] is the most ancient Swiss fossil animal known.

The other *Orthoptera* from the European Coal Measures include *Gryllacris lithanthraca* [2] and *Acridites formosus* [3] from the neighbourhood of Saarbrück; *Pachytylopsis Persenairei* [4] from the Belgian Coal-fields; and one species of *Phasmidæ* from the Upper Coal Measures of Commentry, which has been described by M. Charles Brongniart [5] and named by him *Protophasma Dumasii*. M. Brongniart observes of this species that it approaches *Phasma variegatum* in its neuration.

The only representatives of the *Hemiptera* from the Carboniferous rocks are *Fulgorina* (*Fulgora*) *Ebersi* [6] and *Klieveri* [7] from Saarbrück, and *Macrophlebium Hollebeni* [8] from Mannebach.

The *Coleoptera* are represented by one specimen—*Troxites Germari* [9]—from Saarbrück, and by traces of borings in petrified wood from the Carboniferous Limestone of Autun, which are believed by M. Charles Brongniart [10] to have been made by a species

zosterites, all the species have been distributed by Mr. Scudder amongst new genera created by him, viz., *Etoblattina*, *Gerablattina*, *Anthracoblattina*, *Progonablattina*, *Petrablattina*, *Oryctoblattina*, and *Hermatoblattina*.

1 "Viertelj. Naturf. Gesellsch. Zürich," ix., 287, 291-293, 1864; "Die Urwelt der Schweiz.," 1st edit. (529, Note), 1865; and 2nd edit. p. 24, Zürich, 1879.

2 "Palæontographica," Vol. iv., 1854; "Fauna Saræpontana Fossilis," Heft 1, p. 20, 1873.

3 *Op.* last cited, pp. 18-19.

4 "Ann. Soc. Ent. Belgique," Tome xviii., 1875 (*antea cit.*).

5 "Compte-Rendu. Soc. Ent. Belgique," Serie 11, No. 47 (pp. 9-12), January, 1878; and "Annales des Sciences Naturelles," 6me Serie, Tome 7, 2-4, Article No. 4, 1878.

6 "Palæontographica," Vol. xvi., 1869; "Fauna Sar. Foss.," Heft 2, pp. 28 30, 1877.

7 "Neues Jahrbuch für Min.," 1869; Fauna Sar. Foss.," Heft 2, p. 31, 1877.

8 "Neues Jahrb. für Min.," pp. 158-168, 1869.

9 "Palæontographica," Vol. iv., 1854; and "Fauna Sar. Foss.," Heft 1, p. 7, 1873.

10 "Annales Soc. Ent. France," Vme Series, 1876.

of *Hylesinus*. Dr. Geinitz has also referred similar borings in fossil wood, in the Coal Measures of Saxony, to a beetle which has been named by Dr. Fric *Xyloryctes planus*.

AMERICA.

CARBONIFEROUS.

The fossil insects obtained from the American Carboniferous rocks all belong to the *Neuroptera* and *Orthoptera*.

The *Neuroptera* are represented by thirteen species, viz., *Miamia Bronsoni*[1] and *Danæ*,[2] *Crestotes lapidea*,[3] *Hemeristia occidentalis*,[4] *Megathentomum pustulatum*,[5] *Euephemerites simplex*,[6] *gigas*,[6] *affinis*,[6] and *primordialis*,[7] *Libellula (?) carbonaria*,[8] *Haplophlebium Barnesii*,[9] *Paolia vetusta*,[10] and *Termes contusus*[11].

From the neuration of the wings of the species respectively belonging to the genera *Miamia* and *Hemeristia*, Mr. Scudder is of opinion that each represents a new family of *Neuroptera*, containing peculiarities, both of *Neuroptera* proper and *Pseudo-Neuroptera*. The species belonging to the genus *Termes* (*T. contusus*) is especially interesting as being, I believe, the only fossil specimen of a white ant discovered in America. Amongst the remains referred by Scudder to the genus *Euephemerites* is "the well[12] defined wing of an insect of marked simplicity" (*E. primordialis*). Mr. Scudder observes that in this ancient wing scarcely the slightest differentiation has begun. In this respect, therefore, this wing differs from all others yet discovered; for even in

[1] "Silliman's Journal" (2), Vol. xxxvii., p. 34.

[2] "Geol. Illinois," Vol. iii., p. 566.

[3] *Op.* last cited, Vol. iii., p. 567.

[4] "Sill. Jourl." (2), Vol. xxxvii., p. 34.

[5] "Geol. Ill.," Vol. iii., p. 570.

[6] *Op.* last cited, pp. 472 and 571.

[7] "Proc. Bost. Soc. Nat. Hist.," Vol. xix., p. 37, 1878.

[8] "Proc. Amer. Assoc. Adv. of Science," Vol. xxiv., p. 110; and see "Geol. Mag." (No. 149), Vol. iii., N.S., p. 519, 1876.

[9] Dawson's "Acadian Geology," p. 387, 1868; and "Geol. Magazine" (No. 39), Vol. iv., p. 386, 1867.

[10] "Silliman's Jour." (3).

[11] "Proc. Bost. Soc. Nat. Hist.," Vol. xix., p. 54, 1878.

[12] Proc. last cited, p. 37.

those obtained from the Devonian rocks, the differentiation of the wings is scarcely less perfect than in living insects.

The fossil referred to the genus *Libellula* is supposed to be the abdomen of a larval Dragon-fly ; but it appears to me to be so imperfect and fragmentary, that it is impossible to say to what insect it belonged. It is extremely improbable that this fossil should have belonged to the *Odonata*, which, although abundantly represented in the Jurassic rocks of Solenhofen, and also—though less commonly—in the English Lias, are unknown in rocks of greater antiquity.

The fossil named *Haplophlebium Barnesii*[1] appears to have belonged to the *Ephemeridæ*, and consists of a long narrow[2] wing, about three and a-half inches in length, so that the insect, when expanded, must have measured over seven inches, and have been much larger than any living species of that family. Mr. Scudder says of it—"The extreme simplicity of the neuration probably "places this insect among the *Ephemerina*, although the form of the "wing and the reticulation recall the *Odonata ;* other features of "the wing resemble the *Odonata*, and it is not impossible that "*Haplophlebium* forms a synthetic type, combining essential "characters of *Odonata*[3] and *Ephemerina*."

In alluding to the family (*Ephemeridæ*) to which this gigantic species has been referred, Dr. Dawson observes—"When we con- "sider that the larvæ of such creatures inhabit the water, and "delight in muddy bottoms, rich in vegetable matter, we can easily "understand that the swamps and creeks of Carboniferous Acadia "must have been especially favourable to such creatures, and we can "imagine the larvæ swarming on the deep black mud of the ponds "in these swamps, and furnishing a great part of the food of the "fishes inhabiting them, while the perfect insects emerging from the "waters, to enjoy their brief space of aërial life, would flit in millions "over the quiet pools and through the dense thickets of the Coal "swamps."[4]

[1] Dr. Goldenberg has placed this fossil in the extinct order *Palæodictyoptera* before referred to. "Fauna Sar. Foss.," Heft 2, 1877.

[2] See plate xvii., fig. 1, 391, "Geol. Mag.," September, 1867. See also "A Manual of Palæontology," by Prof. Alleyne Nicholson, M.D., p. 186, fig. 129; and Dawson's "Acadian Geology," p. 387, 1868.

[3] Dr. Dawson is of the same opinion. See "Geol. Mag." (No. 39), Vol. iv., p. 386, 1867.

[4] "Geol. Mag." (No. 39), Vol. iv., p. 386 (*antea cit.*).

With the exception of a cricket—*Archegogryllus priscus*[1]—and a supposed species of *Mantis*,[2] all the *Orthoptera* from the Carboniferous rocks of America (amounting to nineteen in number) belong to the *Blattidæ*[3] (Cockroaches), viz., *Blattina venusta*,[4] *Heeri*,[5] *Bretonense*,[6] *sepulta*,[7] and *fascigera*,[8] *Mylacris anthracophilum*,[9] *Pennsylvanicum*,[10] and *Mansfieldi*,[11] *Archymylacris acadicum*,[12] and *parellelum*,[13] *Necymylacris heros*,[13] and *lacoanum*,[13] *Lithomylacris angustum*,[13] *pittstonianum*[13] and *simplex*, *Gerablattina balteata*,[13] and *Etoblattina Lesquereuxii*.[13]

These seventeen species of Cockroaches have been arranged by Mr. Scudder[14] in two groups—*Mylacridæ* and *Blattinariæ*—in the first of which he has placed *Bretonense*, *Heeri*, *Pennsylvanicum*, *Mansfieldi*, *heros*, *angustum*, *Pittstonianum*, *lacoanum*, *simplex*, and *anthracophilum*; and in the second *sepulta*, *acadicum*, *parallelum*, *Lesquereuxii*, *fascigera*, *balteata*, and *venusta*. With the exceptions of *venusta*, *Heros*, *parallelum*, *fascigera* and *sepulta*, which were obtained from the Millstone Grit,[15] all the other specimens were discovered in the Coal Measures.

[1] "Proc. Bost. Soc. Nat. Hist.," Vol. xi., p. 402.

[2] "Geol. Ill.," Vol. iii., p. 567.

[3] Mr. Scudder has recently divided this family into two groups—*Mylacridæ* and *Blattinariæ*. See "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt 1, No. 3, November, 1879, *antea cit.*

[4] "Owen's 2nd Rep. Geol. Arkansas," p. 314.

[5] "Can. Nat." (N.S.), Vol. vii., p. 272.

[6] *Op.* last cited, p. 271.

[7] "Proc. Amer. Assoc. Adv. Science," Vol. xxiv., p. 111.

[8] "Proc. Bost. Soc. Nat. Hist.," xix., pp. 238-239.

[9] "Geol. Ill.," Vol. iii., p. 568.

[10] "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, 1879.

[11] *Op.* last cited.

[12] "Acadian Geology," p. 388, 1868; and "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No 3, *antea cit.*

[13] *Op.* last cited. With the exception of *B. venusta*, *Heeri*, *Bretonense*, *sepulta*, and *fascigera*, *Mylacris anthracophilum*, and *Archimylacris acadicum*, all these *Blattidæ* have been described by Mr. Scudder in the "Mem. Bost. Soc. Nat Hist.," Vol. iii., pt 1, No. 3 *antea cit.* since the date at which this paper was read.

[14] "Proc. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3 *antéa cit.*

[15] Op. last cited, p. 36.

NOTE.—All the species described or re-described in the work last mentioned have been referred to genera which, with the exceptions of *Mylacris* and *Archymylacris*, were previously uncreated.

DEVONIAN.

The six oldest known fossil insects were obtained by Mr. C. F. Hartt, from the Devonian rocks of New Brunswick. The locality in which they were found has been named by their discoverer "Fern Ledges," and is situated about a mile west of the town of Carleton, near St. John's. The rocks at this place are described as forming a series of ledges exposed on the sea shore between high and low water mark, and consisting of sandstone and fossiliferous shales rich in plant remains. Some doubt as to the age of these rocks has been expressed by Dr. Geinitz,[1] who considered them as probably belonging to the Carboniferous formation from the fact that one of the insects obtained from them was associated with a fern characteristic of that formation; but Dr. Dawson[2] believes that from their containing beds richly stored with Devonian plants, and underlying unconformably the oldest portion of the Carboniferous series, they belong most unquestionably to the Devonian formation, and his opinion has been accepted by all the leading geologists in Europe and America.

As these Devonian insects are the most ancient representatives of their Class yet discovered, they are especially interesting, and are probably worthy of a more detailed notice than has been bestowed in these papers on the majority of those obtained from more modern rocks. They have all been described[3] by Mr. Scudder, and respectively named by him *Xenoneura antiquorum*, *Gerephemera simplex*, *Platephemera antiqua*, *Lithentomum Harttii*, *Dyscritus vetustus*, and *Homothetus fossilis*.

Xenoneura antiquorum and *Gerephemera simplex* were obtained from a lower portion of the shales than any of the others, and are therefore, presumably, the oldest of the six. The first-named fossil, *X. antiquorum*, appears to be the basal portion of a small wing, which was probably about two inches in expanse. From the peculiar nature of its neuration Mr. Scudder is of opinion that it represents an extinct family of *Neuroptera*, and probably belonged

1 "Sitzungsb. der Naturf. Gesellsch." Isis, Dresden, 1866.

2 "Geol. Mag.," Vol. iv., p. 386, 1867.

3 See Bailey's "Observations on the Geology of Southern New Brunswick," Appendix A., pp. 131-141, 1865; "Geol. Mag.," Vol. v., pp. 175-176; Vol. iv., pp. 387-388; "Acadian Geol.," *antea cit.*, p 525; and Dana's "Manual," *antea cit.*, p. 273-274.

to a group constituting a synthetic type between the *Orthoptera* and *Neuroptera*. He observes that the most striking peculiarity in this specimen is the development of apparently independent veinlets, forming portions of concentric rings, at the base of the wings, which he compared to the stridulating organ of some male saltatorial *Orthopteron*. Dr. Dawson,[1] in alluding to this peculiarity in this specimen, remarks that "nothing is more curious than the "apparent existence of a stridulating or musical apparatus, like that "of the cricket, in an insect otherwise allied to the *Neuroptera*. "This structure also," continues Dr. Dawson, "if rightly inter-"preted by Mr. Scudder, introduces us to the sounds of the Devonian "woods, bringing before our imagination the trill and hum of insect "life that enlivened the solitudes of these strange old forests."[2]

The second specimen, *G. simplex*, consists of a fragment of the tip of a large broad wing, which appears to have belonged to a member of the *Ephemerina*.

The third specimen, *P. antiqua*, is believed to be a portion of the upper wing of a gigantic species of the *Ephemerina*, which must have measured five inches in expanse of wings, and from its combination of peculiarities[3] of structure now only found in different groups must also be regarded as a "synthetic type."

The fourth specimen, *L. Harttii*, is supposed to be a portion of the lower wing of a *Neuropterous* insect, measuring about three and a-half inches in expanse of wings, and allied to the *Sialina*, but not belonging to any family represented among existing forms.

The fifth specimen, *D. vetustus*, is represented by so small a fragment of a wing that Mr. Scudder considers it impossible to determine the approximate size of the insect, or the family to which it belonged, though its characters are clear enough to show it was *Neuropterous*, and to distinguish it with certainty from the other specimens.

The last specimen, *H. fossilis*, consists of the greater portion of the upper wing of an insect, which Mr. Scudder believes to be the representative of another new family of *Neuroptera*, "synthetic in nature, combining features of the *Odonata* and *Sialina*;" and he

[1] See plate xvii., "Geol. Mag.," Vol. iv., p. 390.

[2] "Geol. Mag.," Vol. iv., p. 387, 1867; and "Acadian Geology," pp. 524-525, *antea cit.*

[3] Mr. Scudder observes of this specimen—"The intercalary nervules which in *Ephemerina* generally originate independently, arise here from a bent cross-vein much as in *Odonata*." "Geol. Mag," Vol. v., p. 175, 1868.

adds that though it is in a mutilated condition the extent and character of every principal nervure can be determined.

The most noticeable peculiarity of this specimen appears to be a heavy cross vein near the base of the wing—between the principal middle nervures—and from which cross vein new prominent veins take their rise.

Although these Devonian insects are the oldest specimens yet discovered, the families to which they belonged had doubtless existed for ages; and it must not be assumed that even their family types necessarily, or even probably, represented the earliest forms of insect life. In all other classes of the Animal Kingdom, with whose fossil remains we are acquainted, as well as in the Vegetable Kingdom, the simpler forms precede the more highly organised. There seems no reason for supposing that the *Insecta* formed any exception to this rule, and we may fairly assume that the earliest types of this class were likely to have been larger in size, simpler in form, and less specialized than these remarkable *Neuropteroid* insects of the Upper Devonian period; and that they had probably existed for ages before that epoch, as had representatives of the *Crustacea*, the *Mollusca*, and even the *Vertebrata*.[1]

Reasoning from the analogy which one may assume to exist between the *Insecta* and other Classes of the Animal Kingdom in progressive development, it seems highly probable that further researches in earlier Devonian strata, and possibly in rocks of even greater age (Silurian), may bring to light more ancient forms of insect life than any yet discovered.

The appearance of insects on the Earth was probably synchronous with that of land plants,[2] and as remains of this division of the Vegetable Kingdom have been discovered in rocks belonging to the Upper Silurian[3] period, the existence of a land flora, ages before the date at which these Devonian insects lived, is proved. The fact of the existence of land plants[4] at as early a date as the

[1] The oldest known type of fishes is described by J. W. Salter, F.G.S. in the "Annals and Mag. of Nat. Hist.," Vol. iv., 1859.

[2] It is not impossible, however, that insects may have appeared before land plants, which were not absolutely necessary to the existence of groups similar in their nature to the *Odonata* and *Ephemerina*, which are essentially carnivorous and aquatic in their early stages.

[3] Dana's "Manual of Geology," *antea cit.*, p. 245; and "The Origin of the World," by Dr. Dawson, F.R.S., p. 330, London, 1877.

[4] "In the Upper Ludlow beds (Silurian Period) occur seed vessels called *Pachytheca* by Hooker, and also fragments of stems supposed to be

close of the Silurian period appears to me to be an additional reason to those previously given for assuming the probability of the first appearance of insects at a much earlier age than that of the Devonian shales at "Fern Ledges."

I have, I believe, now enumerated all the known fossil insects which have been obtained from the Palæozoic rocks of the United Kingdom, and the Continents of Europe and America.

The 122 species which have been named and described are Geographically distributed as follows:—

From the United Kingdom[1] .	. 5
„ Continent of Europe	. 79
„ „ America	. 38
Total	. 122

The Geological distribution of these fossils is as follows:—

From the Permian . .	. 13
„ Carboniferous . .	. 103
„ Devonian . .	. 6
Total .	. 122

CONCLUSION.

Having in this and the two[2] preceding papers called attention to those formations of the Post Tertiary, Tertiary, Secondary, and Primary Periods, from which insects have been obtained, and having enumerated the Orders, Families, Genera, and, in many cases, the species to which these fossils have been referred, I propose to offer a few suggestions, as to some of the conclusions which may be arrived at, from a consideration of the facts which have been adduced.

those of *Lycopods* (ground pines). In Germany, at Lobenstein, and at Hostin in Bohemia, *Lycopods* of the *Lepidodendron* family occur. . . . . Besides these flowerless species (Cryptogams), others of genera of the pine tribe—the lowest division of flowering plants (Phenogams)—are supposed by Dawson to have existed, and he has referred pieces of carbonised wood from the Upper Ludlow beds to the genus *Proto-taxites*" (πρῶτος first, and *taxus* yew tree). Dana's "Manual of Geology," *antea cit.*, p. 245.

[1] There are, I believe, several species in the collections of the Rev. P. B. Brodie and others which have not yet been described.

[2] See "Proc. Geol. Assoc.," Vol. v. (No. 6), pp. 282, 343, April 1878; and Vol. vi. (No. 3), pp., 116-150, July 1879.

Let us consider (firstly) what information is afforded by Palæontology on the questions of the origin and progressive development of insects; the order of the apparition of the various groups on the Geological horizon; the antiquity of many of their existing genera; and (secondly) what inferences may be drawn as to the land and fresh water conditions of the Earth, of its climate and vegetation in any former Period, and of the contemporaneous existence of other Classes of the Animal Kingdom from a study of the fossil insects of such Period.

Before proceeding to show what evidence has as yet been furnished by Palæontology, in support of the opinions of many Biologists, as to the evolution or gradual progression of the existing Orders of Insects from some primitive type, it will be necessary to refer briefly, to the writings on this subject of Prof. Haeckel, Dr. Fritz Müller, and Sir John Lubbock.

Prof. Haeckel and many other Biologists are of opinion that the *Crustacea*, *Myriopoda*, *Arachnida*, and *Insecta*, must have had a common ancestor, from which the *Crustacea* first, and through it, the other Classes of the *Arthropoda* are descended.

Dr. Fritz Müller[1] is of opinion that the water-inhabiting and water-breathing *Crustacea*, must be regarded as the original stem, from which the other terrestrial Classes of the *Arthropoda*, with their tracheal respiration, have branched off.

Sir John Lubbock,[2] writing on the origin and metamorphoses of Insects, observes—"there are good grounds for considering "that the various types of insects are descended from ancestors "more or less resembling the genus *Campodea*,[3] with a body divided "into head, thorax, and abdomen; the head provided with mouth "parts, eyes and one pair of antennæ; the thorax with three pairs of "legs; and the abdomen, in all probability, with caudal appendages. "If these views are correct the genus *Campodea* must be regarded as "a form of remarkable interest since it is the living representative of "a primæval type from which not only the *Collembola* and *Thysanura*, "but the other great Orders of insects have derived their origin."

I have felt great reluctance in giving garbled extracts from the works of these eminent authorities, and venturing to allude to their opinions in so cursory a manner; but as some excuse for doing so I

[1] "Facts for Darwin" (translated from the German of Dr. Fritz Müller, by W. S. Dallas), Chap. xi., p. 120, 1876.

[2] "On the Origin and Metamorphoses of Insects," by Sir John Lubbock, Bart., M.P., F.R.S., Ch. v., p. 92, 1874.

[3] An existing genus belonging to the order *Thysanura*.

would observe that it is not within the scope of this paper to discuss the questions of the probable origin and progressive development of insects from Biological data, but merely to call attention to such facts, bearing on the subject, as have been obtained by the researches of the Geologist and Palæontologist; which facts would, however, be scarcely intelligible in their application, without at least an allusion to some of the opinions, before quoted, on these questions.

It must be admitted that, up to the present, we have no record of the discovery in any rocks—even in the most ancient—of any forms of insects which are, *at first sight*, connecting links between existing types and simpler organisms. On this point Sir John Lubbock observes,[1] that "the earliest known *Neuroptera* and "*Orthoptera*, though in some respects less specialized than existing "forms, are as truly and as well characterized insects as any now "existing; nor are we acquainted with any earlier forms which in "any way tend to bridge over the gap between them and lower "groups, though, as we shall see, there are types[2] yet existing which "throw much light on the subject."

Even apart from the opinions of the distinguished Biologists before quoted, it would be unreasonable to suppose that the oldest known *Neuroptera* and *Orthoptera*—even though many of them are less specialized than existing forms—represent the earliest types of the Class to which they belong; and we may confidently expect that with the progress of Geological research in the Devonian, and very possibly in the Silurian[3] formations, traces of the former existence of winged insects, simpler in form, and even more generalized in structure than any yet discovered, may be brought to light.

Making due allowance for the comparative shortness and incompleteness[4] of the Geological record, the opinions of Biologists on

[1] "On the Origin and Metamorphoses of Insects," Ch. v., p. 86, *antea cit.*

[2] i.e. *Campodea*, referred to on the previous page.

[3] Remains of land plants have been discovered in rocks of Lower Silurian age.

[4] Mr. Darwin's remarks on this point are especially apt—"I look at the geological record as a history of the world imperfectly kept, and written in a changing dialect; of this history we possess the last volume alone, relating only to two or three countries. Of this volume only here and there a short chapter has been preserved; and of each page only here and there a few lines. Each word of the slowly changing language more or less different in the successive chapters, may represent the forms of life which are entombed in our consecutive formations, and which falsely appears to us to have been abruptly introduced." "The Origin of Species," by Charles Darwin, F.R.S., 6th edit., p. 289.

the subject of the progressive development of the various Orders of insects, seem to be borne out by the results of such Palæontological researches as have yet been made; and we find that the relative subordination of the existing groups is pretty much in accordance with the order of their Geological succession, the simpler forms preceding the more highly organized. Some of the oldest known insects were, as we have seen, much less specialized than those of the present day, and many of them combined peculiarities of structure now characteristic of separate Orders, such as combinations of characters of *Neuroptera* and *Orthoptera*, of *Neuroptera* and *Hemiptera*, or of *Neuroptera* proper and *Pseudo-Neuroptera*.

These synthetic types, however, were associated with representatives of the most recent forms, and even some of the Devonian Insects—the most ancient known—are, according to Mr. Scudder,[1] to be "referred with very little question not only to the *Neuroptera*, "but even to a particular family of *Neuroptera* now existing—the "May flies. Indeed the presence, at the apparition of a given "group, of modern types side by side with those which elude our "classification of existing forms is one of the peculiar problems of "Palæontology."

Notwithstanding the occurrence of recent types in the most ancient rocks, the rule that the simpler forms precede the more highly organized, holds good in the main, the oldest *Neuroptera* being represented, almost invariably, by species with incomplete metamorphoses, and the oldest *Orthoptera* including—with the exception of a few *Phasmidæ*, and *Gryllidæ*—hardly any species, except *Blattidæ*, which are more numerous than all the other Palæozoic Insects.

The great rarity of the remains of the *Hemiptera* and *Coleoptera* in the Palæozoic rocks prevents us from ascertaining whether they, like the *Neuroptera* and *Orthoptera*, were chiefly represented at this early period, by their lowest[2] families.

The scarcity of representatives of these two Orders in Palæozoic rocks can, I think, only be explained on the hypothesis that they

1 "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 2, 1879.

2 Since writing this I have read Mr. Scudder's remarks on the Palæozoic *Hemiptera*, which are as follows:—"We may glean still another fact from the scanty data the rocks afford us concerning the early types of Insects. All the *Hemiptera* of the Palæozoic rocks belong to the *Homopterous* division of this sub-Order, indicating what is generally conceded, that this division is lower than the *Heteroptera*, which first appeared in the Jura." "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 2, *antea cit.*

made their appearance much later than the *Neuroptera* and *Orthoptera*; had they been fully developed at as early a period as the two Orders last named, their remains would certainly have been preserved at least as commonly as remains of those Orders. This is especially true of the *Coleoptera*, which, from the hardness of their elytra, are capable of preservation under much less favourable conditions than is requisite for the preservation of insects of most orders; and in the rocks of the Secondary and Tertiary Periods, fossils of this Order of Insects are, as a rule, far more abundant than those of any other Order of Insects.

As we have seen, only two species of *Coleoptera* are known from the Palæozoic rocks, and only three from the Trias; but from the Rhœtics several are recorded, and from the Lias great numbers have been obtained; and from this remote period to the present time the *Coleoptera* appears to have been a dominant Order, though, as previously observed, representatives of this class have, from their nature, doubtless been preserved in much greater numbers than insects of most Orders, and may thus appear to have been comparatively more abundant than they really were.

Returning to the *Hemiptera*—it will be remembered that only three species of this Order are recorded from the Carboniferous rocks, and two from the Permian. No species of this Order have yet been discovered in the Trias, but a few are recorded from the English Lias, and several from the Lias of Schambelen.

One or two supposed species of *Diptera*[1] are recorded from the English Lias, but no remains of this Order are known from any Continental formations older than the Solenhofen slate. Both this Order and the *Hymenoptera* appear to be sparingly represented in the Purbecks; but it is not until we reach the formations of the Tertiary age that we find either of them generally distributed or abundantly represented. As Prof. Heer observes—the date of the appearance of these Orders must have depended upon the state of development of the vegetable kingdom, and insects which resort to flowers for their nourishment, could not have existed prior to the period at which the dicotyledonous plants attained a high stage of perfection.

The most modern Order is apparently the *Lepidoptera*, no remains of which are recorded from any strata older than the Stonesfield

[1] Of one of them Prof. Westwood observes—"Seems like the body of a Tipulideous insect." Of another fragment he says, "May possibly be *Dipterous* allied to *Asilus*." Brodie's "Fossil Insects," p. 128.

slate. From this formation, as I have already noticed in my second[1] paper, remains of two *Lepidopterous* (?) insects have been obtained, one of which has been described and figured by Mr. Butler in his "Lepidoptera Exotica" as *Paleontina Oolitica.* The question of whether or not this fossil should be referred to the *Lepidoptera*, or to the *Hemiptera* (*Homoptera*), having been discussed at some length in the paper last mentioned, I shall not further allude to it.

With the exceptions of *Paleontina Oolitica*, of two *Lepidopterous*[2] insects from the Solenhofen Slate, and the two very[3] doubtful fragments from the Purbecks, we have no record of the discovery of any well authenticated fossil insects of this Order from older strata than the upper division of the Lower Tertiaries. From formations of this period about twenty-six species of *Lepidoptera* (exclusive of those found in Amber), have been recorded, namely, four from strata of Upper Miocene age, eight from the Middle Miocene, four from the Lower Miocene, and ten (five *Rhopalocera*) from the Upper Eocene. Of these twenty-six species of *Lepidoptera*, ten have been referred to the *Rhopalocera* (or Butterflies), and the remaining sixteen to the *Heterocera* (or Moths).

Of the ten species of butterflies, five have, as I remarked in my first paper, been obtained from formations of the Upper Eocene period, but none have been recorded from older strata of the Tertiary Age.

From the evidence at present obtained by Palæontology, it appears that the *Neuroptera* is the oldest of the existing Orders; that it was followed by the *Orthoptera*, and that these two Orders included *almost all*[4] the insects of the Primary or Palæozoic period, towards the close of which the *Hemiptera* and *Coleoptera* began to appear; that comparatively early in the Secondary or Mesozoic Period, the two last named Orders became abundant and widely distributed, and somewhat later were followed by the *Diptera*, and some families of the *Hymenoptera;* and, further, that towards the close of this period other families of the *Hymen-*

[1] See "Proc. Geol. Assoc.," Vol. vi., No. 3; pp., 126 and 127. July, 1879.

[2] *Sphinx Snelleni* and *Pseudosirex Darwini.*

[3] *Cyllonianum Boisduvalianum* and *C. Hewitsonianum.*

[4] It must, of course, be understood that those ancient types, which, from their combination of the characters of two or more orders or families of insects, have been placed by Dr. Goldenberg in the extinct order (*Palæodictyoptera*) before referred to, are excepted from this generalization.

optera—including the Bees—appeared, and were accompanied, or immediately followed, by the *Lepidoptera*, which last Order, however, does not appear to have been thoroughly established much before the close of the Eocene Division of the Tertiary Period.

In attempting to arrive at any conclusion as to the origin and evolution of Insects, and the order of their Geological succession, from a consideration of the facts derived from Palæontology, the shortness and incompleteness of the Geological record must always be borne in mind, and, as Mr. Darwin[1] remarks, "The crust "of the earth, with its embedded remains, must not be looked at "as a well filled Museum, but as a poor collection made at hazard, "and at rare intervals."

The force of these observations is especially felt in the particular branch of Palæontology which is the subject of these papers. Although, as we have seen, fossil insects have in certain strata, and in a few widely scattered localities, been obtained in considerable numbers, they appear to be, as a rule, extremely rare; and consequently afford but few data on which to base satisfactory generalizations as to their probable origin, order of succession, and geographical distribution in former ages.

The course of progression through which insects are considered by many Biologists to have attained to their present condition, and the primary relations of the various Orders, have been fully discussed by Sir John Lubbock,[2] Mr. Darwin,[3] Professor Haeckel,[4] Dr. Fritz Müller,[5] Dr. Packard,[6] Mr. Scudder,[7] and others.

The great antiquity of many of the existing genera of insects, as compared with that of the genera of the Vertebrates, and the very small amount of change[8] which has taken place in many of

[1] "The Origin of Species," Ch. xiv., p. 487 (1859).

[2] "On the Origin and Metamorphoses of Insects," *antea cit.*

[3] "The Origin of Species," *Antea cit.*

[4] See "The History of Creation" (an English translation of "Natürliche Schöpfungsgeschichte") by Dr. Ernst Haeckel, 1874; the translation revised by Prof. E. Ray Lankester, 1876.

[5] "Facts and Arguments for Darwin" (translated from the German, by W. S. Dallas, 1869).

[6] "Embryological Studies on Hexapodous Insects," Mem. Peabody Academy of Science, Vol. v., pt. 1, No. 3. "On Synthetic Types in Insects." Bost. Jourl. Nat. Hist., Vol. vii, 591-2; and "Guide to the Study of Insects," 1869.

[7] "The Early Types of Insects." Mem. Bost. Soc. Nat. Hist., Vol. iii., pt. 1, No. 2, 1879.

[8] "The general type of wing structure in insects has remained unaltered from the earliest times." See the paper last cited, p. 21.

them during the Geological record, is very remarkable. The truth of this must be apparent to any one who compares a list of the fossil insects of any Period with a list of the fossils of almost any other Class of the Animal Kingdom, which existed during the same Period. If we take any Order of insects—say the *Coleoptera*—and enquire what families of that Order were represented in the "Purbecks," we shall find *Buprestidæ*, *Carabidæ*, *Curculionidæ*, *Chrysomelidæ*, *Elateridæ*, *Cantharidæ*, *Tenebrionidæ*, &c. Now all these are existing families, represented at the present day by a great number of species. In what other division of the Animal Kingdom—at any rate amongst the *Vertebrata*—should we find so many families which existed during any part of the Jurassic Period represented at the present day?

Compare the fossils of the English Lias with the existing Orders of the Animal Kingdom. It will be seen[1] that the insect remains of this period have been referred to species distributed amongst the *Carabidæ*, *Telephoridæ*, *Elateridæ*, *Curculionidæ*, *Chrysomelidæ*, *Blattidæ*, and *Gryllidæ*, all of which families are represented at the present day; but, with regard to the *Vertebrata*, where are the representatives at the present day of the Saurians, the flying lizards, and other gigantic reptiles of the Lias? "When we consider," says Mr. Alfred Russell Wallace,[2] "that almost the "only Vertebrata of this period (*i.e.*, the Lias), were huge Saurian "reptiles like the *Icthyosaurus*, *Plesiosaurus*, and *Dinosaurus*, with "the flying Pterodactyles, and that the great mass of our existing "genera, and even families of fish and reptiles, had almost certainly "not come into existence, we see at once that the types of insect "form are proportionately far more ancient. At this remote epoch "we find the chief family types (the genera of the time of Linnæus) pefectly differentiated and recognizable."

I will now endeavour to suggest a few of the most important conclusions bearing upon the land and fresh-water conditions of the Earth in former ages, which may be arrived at from a study of fossil insects.

From the fact that some insects are aquatic, and some terrestrial, and that some are carnivorous, some herbivorous and some pre-

[1] See list of species at the end of the 2nd paper. "Proc. Geol. Assoc., Vol. vi., No. 3, July, 1879.

[2] "The Geographical Distribution of Animals," Vol. i., p. 167, 1876.

daceous in their habits, it is evident that the prevalence of the remains of any group or family of animals of this Class, in a fossil state, furnishes an important clue to a knowledge of the land and fresh-water conditions of the Earth, and of its climate and vegetation during the period of their existence; and Sir Charles Lyell[1] has remarked "that if this Class of the Invertebrata were "not so rare and local, they might be more useful than even the "plants and shells in settling chronological points in geology."

Where we find aquatic insects fossilized in large numbers in any strata, we necessarily infer the presence of rivers or fresh-water lakes; and the discovery of the remains of numbers of herbivorous insects in any formation certainly implies the former prevalence of a more or less luxuriant vegetation.

Fossil insects also furnish some evidence as to the contemporaneous existence of other Classes of the Animal Kingdom; for instance—the discovery in the Swiss Lias of the remains of coprophagous beetles, whose representatives of the present day are found in the dung of cattle, leads to the inference of the contemporaneous existence of some species of Mammalia, even although no traces of them have been detected in that formation; and the Rev. P. B. Brodie observes that, "the presence of insects in "any formation shows that there must have been animals which "preyed upon them, remains of which have been discovered in the "Oolite (including therein the Purbecks), wherein we have insec-"tivorous mammals."

Finally, I would observe that the conclusions arrived at by Prof. Heer,[2] from a study of the fossil flora of Europe, as to the various changes of climate which the Continent has undergone in past ages, have been, to a great extent, confirmed by his subsequent examination of the fossil insects of Europe, and a comparison of their families, genera, and species, with those of the existing insect fauna and their geographical distribution.

[1] "Elements of Geology," 6th edit., p. 255.

[2] "Untersüchungen ueber das Klima und die Vegetations Verhaltnisse des Tertiärlandes." Winterthur, 1860. See also the French translation, by Dr. Gaudin, "Recherches sur le Climat et la Végétation du Pays Tertiaire." Paris, 1861.

A LIST OF INSECT REMAINS DISCOVERED IN THE FORMATIONS OF THE PALÆOZOIC PERIOD.

EUROPE.

GREAT BRITAIN.

CARBONIFEROUS.

From the Ironstone of Coalbrook Dale, Shropshire.

ORTHOPTERA.

Gryllacris (Corydalis) Brongniarti.

COLEOPTERA

Curculioides Ansticii.

From the Coal Measures on the north bank of the Wear, opposite Claxheugh, near Sunderland.

ORTHOPTERA.

Phasmidæ? (supposed species of).
Blattidium mantidioides [1]

From the Scottish Coal-fields in the neighbourhood of Glasgow.

ORTHOPTERA.

Lithomantis carbonarius.

CONTINENTAL EUROPE.

PERMIAN, OR DYAS.

From Schwarzenbach, Birkenfeld, Cassel.

PALÆODICTYOPTERA.

Eugereon Böckingi.

HEMIPTERA.

Fulgorina (Fulgora) Ebersi.

From Stockheim, Bavaria.

PALÆODICTYOPTERA.

Ephemerites Rückerti.

ORTHOPTERA.

Blattina Rückerti.[2]

From Weissig, Saxony.

ORTHOPTERA.

Blattina Weissigensis.[3]	Blattina anthracophila (flabellata).[2]
„ porrecta.[4]	„ carbonaria.[3]
„ didyma (sopita).	„ Mahri.

[1] Referred by Scudder to the genus *Etoblattina*.
[2] „ „ „ *Anthracoblattina*.
[3] „ „ „ *Etoblattina*.
[4] „ „ „ *Anthracoblattina*.

From Lebach, near Saarbrück in the Rhenish Provinces of Prussia.

ORTHOPTERA.

Blattina lebachensis.[1]
„ gracilis.[2]

HEMIPTERA.

Fulgorina (Fulgora) lebachensis.

CARBONIFEROUS.

From the neighbourhood of Saarbrück, in the Rhenish Provinces of Prussia.

PALÆODICTYOPTERA.

Dictyoneura libelluloides.
„ anthracophila.
„ formosa.
„ Decheni.
„ elegans.
Dictyoneura elongata.
„ Schmitzii.
„ obsoleta.
„ Humboldtiana.

NEUROPTERA.

Termes Heeri.
„ affinis.
„ Hageni.
„ Buchi.
Termes laxa.
Termitidium amissum.
„ rugosum.

ORTHOPTERA.

Gryllacris lithanthraca.
Acridites formosus.
„ carbonatus.
Blattina primæva.[3]
„ labachensis.[3]
„ insignis.[3]
„ winteriana.[4]
„ intermedia.[5]
Blattina scaberata.[5]
„ Wemmetsweileriensis.[6]
„ Remigii.[7]
„ weissiana.[8]
„ Tischbeini.
„ venosa.
Polyzosterites granosus.

HEMIPTERA.

Fulgorina (Fulgora) eberzi.
Fulgorina (Fulgora) klieveri.

COLEOPTERA.

Troxites Germari.

[1] Referred by Scudder to the genus *Hermatoblattina.*
[2] „ „ „ *Petrablattina.*
[3] Referred by Scudder in his recent paper in the "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 3, to the genus *Etoblattina.*
[4] „ „ „ *Anthracoblattina.*
[5] „ „ „ *Gerablattina.*
[6] „ „ „ *Hermatoblattina.*
[7] „ „ „ *Anthracoblattina.*
[8] „ „ „ *Gerablattina.*

From Manebach, near Ilmenau, in Saxe Weimar.

ORTHOPTERA.

Blattina didyma.[1]
„ Manebachensis.[1]
„ Goldenbergi[2]
„ clathrata.[2]
Blattina Mahri.[2]
„ Fritschii[3]
„ latinervis.

HEMIPTERA.

Macrophlebium Hollebeni.

From Wettin and Lobejün, Prussian Saxony.

ORTHOPTERA.

Blattina euglyptica.[4]
„ affinis.[4]
„ flabellata.[4]
„ anthracophila.[4]
„ Dorhnii.[4]
„ anaglyptica.[4]
Blattina carbonaria.[4]
„ didyma.[4]
„ russoma.[4]
„ leptophlebica.[4]
„ parvula.[4]

ORTHOPTERA.

Blattina spectabilis.[5]
„ Geinitzi.[6]
„ Münsteri.[6]
Blattina producta.[6]
„ Germari.[6]
„ reticulata.[7]

From Klein-Opitz, near Dresden, Saxony.

ORTHOPTERA.

Blattina Dresdensis.[8]

From Erbignon, Valais, Switzerland.

ORTHOPTERA.

Blattina helvetica.[9]

From Sars-Longchamps, Mons, Belgium.

PALÆODICTYOPTERA.

Omalia macroptera.

NEUROPTERA.

Breyeria Borinensis.
Termes ? (a supposed species of).

[1] Referred by Scudder in his recent paper in the "Mem. Bost. Soc. Nat. Hist.," Vol. iii., pt. 1, No. 8, to the genus *Etoblattina*.
[2] „ „ „ *Gerablattina*,
[3] „ „ „ *Progonoblattina*.
[4] „ „ „ *Etoblattina*.
[5] „ „ „ *Anthracoblattina*.
[6] „ „ „ *Gerablattina*.
[7] „ „ „ *Oryctoblattina*.
[8] „ „ „ *Anthracoblattina*.
[9] „ „ „ *Progonoblattina*.

ORTHOPTERA.
Pachytylopsis Persenairei.

From Commentry, Allier, France.

ORTHOPTERA.
Protophasma Dumasii.

AMERICA.

CARBONIFEROUS.

From the neighbourhood of Sydney, Cape Breton.

PALÆODICTYOPTERA.
Haplophlebium Barnesii.

NEUROPTERA.
Libellula (?) carbonaria.

ORTHOPTERA.

Blattina Heeri.[1]
„ Bretonense.[1]
Blattina sepulta.

From Mazon Creek, and elsewhere, near Morris, Danville, and Colchester, Illinois.

PALÆODICTYOPTERA.
Paolia vetusta.

NEUROPTERA.

Miamia Bronsoni.[2]
„ Danæ.[2]
Megathentomum pustulatum.
Euephemerites simplex.
„ gigas.
Crestotes lapidea.
Hemeristia occidentalis.
Euephemerites affinis.
Termes contusus.

ORTHOPTERA.

Mantis ? (supposed species of).
Mylacris anthracophilum.
Lithomylacris simplex.

From Cannelton, Beaver Co., and Pittston, Luzerne Co., Pennsylvania.

NEUROPTERA.

Euephemerites primordialis.

[1] These two species have been re-described by Mr. Scudder in the paper before mentioned (" Mem. Bost. Soc. Nat. Hist.," Vol. iii.), and referred to the genus *Mylacris*.

[2] Both these species have been referred by Goldenberg to the extinct order *Palæodictyoptera*.

ORTHOPTERA.

Archymylacris parallelum.
Mylacris Pennsylvanicum.
„ Mansfieldi.
Neoymylacris heros.
„ lacoanum.
Lythomylacris angustum.
„ pittstonianum,
Etoblattina Lesquereuxii.
Blattina fascigera.[1]

From Frog Bayou, Arkansas.

ORTHOPTERA.

Blattina venusta.[2]

From Picton, Nova Scotia.

ORTHOPTERA.

Mylacris acadicum.

From Tallmadge and Bellaire, Ohio.

ORTHOPTERA.

Archegogryllus priscus.
Gerablattina balteata.[3]

DEVONIAN.

From "Fern Ledges," near Carleton, St. John's, New Brunswick.

NEUROPTERA[4] AND PSEUDO-NEUROPTERA.

Xenoneura antiquorum.
Gerephemera simplex,
Platephemera antiqua.
Lithentomum Harttii.
Dyscritus vetustus.
Homothetus fossilis.

[1] Recently referred by Scudder to the genus *Gerablattina*.

[2] „ „ „ *Etoblattina*.

[3] A second specimen of this species is recorded by Scudder from Cassville, Western Virginia.

[4] These insects have been placed by Dr. Goldenberg in the extinct Order *Palæodictyoptera*; but Mr. Scudder considers Goldenberg to have "gone too far" in referring them to this Order.

ORDINARY MEETING.

January 2nd, 1880.

Professor T. Rupert Jones, F.R.S., &c., President, in the Chair.

The Donations to the Library received since the previous meeting were announced, and the donors received the thanks of the Association.

The following Paper was read :—

On the Geological and other Causes that Affect the Distribution of the British Flora.

By G. S. Boulger, F.L.S., F.G.S.

SPECIAL GENERAL MEETING.

February 6th, 1880.

Professor T. Rupert Jones, F.R.S., &c., President, in the Chair.

The President read the notice by which, in accordance with Rules XXI. and XXVI., the General Committee had convened the meeting, which was as follows :—

"A Special Meeting of the Association will be held at University College, Gower Street, W.C., on Friday, February 6th, 1880, at 7.30 p.m., for the purpose of taking into consideration the alteration of Law XV., as announced at the last Ordinary Meeting, on January 2nd, thus :—

Law XV. as it is at Present.

"That the management of the Association be vested in a President, four Vice-Presidents, a Treasurer, an Honorary Secretary, an Honorary Librarian, and twelve other Members, who shall constitute a General Committee, to be elected annually at the Annual General Meeting, by ballot; the senior Vice-President and the two Senior Members of the General Committee, who shall not

have held during the preceding year any other office, shall not be eligible for re-election to their respective offices until the next Annual General Meeting."

Proposed Alteration.

"That the management of the Association be vested in a President, four Vice-Presidents, a Treasurer, a Secretary, an Editor, a Librarian, and twelve other Members, who shall constitute a General Committee, to be elected annually at the Annual General Meeting by ballot; the senior Vice-President and the two Senior Members of the General Committee, who shall not have held during the preceding year any other office, shall not be eligible for re-election to their respective offices until the next Annual General Meeting."

The President then stated the object of the proposed alteration in Law XV., and explained why the General Committee recommended its adoption; after which the proposition was put to the meeting, when it was carried unanimously, and the President declared the Special General Meeting at an end.

ANNUAL GENERAL MEETING.

FEBRUARY 6th, 1880.

Professor T. RUPERT JONES, F.R.S., &c., President, in the Chair.

The Secretary read the following

REPORT OF THE GENERAL COMMITTEE FOR THE YEAR 1879.

Your Committee have again, as on the last occasion, to regret the small number of new Members elected during the past year, and now as then they find that this is by no means peculiar to this Association, but has happened to other scientific societies in the Metropolis. This falling off is probably to be attributed in part to such continued depression in so many branches of industry as to

draw away the attention of those whose occupations are not purely of a scientific nature—those, in fact, who constitute the great bulk of the members of these societies, from the pursuit of science in their leisure hours; with the return of commercial prosperity we may reasonably hope for a large increase in the number of our Members. In part, also, the decrease is to be attributed to the many local societies that have lately come into existence, some of which, indeed, may almost be said to be offshoots of this Association; this, however, will in the end probably increase the number of our Members by fostering a taste for scientific pursuits.

Members elected during 1879		27
Deaths	5	
Withdrawals and exclusions	21—	26
Increase		1

The Census of the Association on January 1, 1880, was as follows:—

Honorary Members	15
Life Members	69
Old Country Members	20
	104
Other Members	311
	415

The following Members have died during 1879:—Dr. Ogier Ward, Rev. J. Cornthwaite, Mr. W. Newall, Colonel J. J. Gibb, and Miss Jelly.

The decrease in the number of our Members has of course given rise to a falling off in the Income of the Association, and as there also happens to have been, during the past year, an unusually heavy expenditure on account of printing—for which, however, it is to be hoped, the Members have had full value, the expenses have somewhat exceeded the income. As it is not desirable that this should happen without urgent necessity, your Committee are fully alive to the advisability of economy.

The additions to the Library during the past year are numerous, and include amongst others an important series of papers on the Pre-Cambrian rocks of England, by Dr. Hicks, to whom the Society is indebted for their presentation.

A list of these additions will shortly be published for the use of Members.

Your thanks are again due to Mr. E. Litchfield for the great assistance he has rendered on Meeting-nights by his kindness in superintending the issue and return of books.

The following Museums and Geological Collections were visited during 1879 :—

British Museum—
Where Prof. Seeley, F.R.S., gave a demonstration on Dinosauria.

British Museum—
Where Dr. Henry Woodward, F.R.S., gave a demonstration on Cephalopoda.

College of Surgeons—
Where Prof. Flower, F.R.S., gave a demonstration on Cetacea.

At Mr. Piper's house, Ledbury—
A Collection of Silurian Fossils of the neighbourhood was examined by those who took part in the Excursion to Ledbury.

The Excursions during the past year have been unusually numerous, and on the whole well attended, notwithstanding the ungenial spring and summer.

The longer Excursions were all to districts lying to the westward of London, and embraced a considerable variety of formations ; but the chief feature of the season was a series of Excursions from the London Tertiary Basin to the summit of the Weald.

These Excursions, five in number, were most ably directed by Mr. Lobley, whose time and intimate acquaintance with the geology of the district south of the Thames have been so often at the disposal of the Association. Those Members who are unable to go far afield were thus afforded an excellent opportunity for studying the physiography of that remarkable region which forms

the southern curve of the London Basin in the western part of Kent.

A list of all the Excursions, giving the Localities, Directors, and principal Formations, is subjoined.

LOCALITIES.	DIRECTORS.	PRINCIPAL FORMATIONS.
Weymouth & Portland.	Rev. J. F. Blake, M.A., F.G.S. W. H. Hudleston, Esq., M.A., F.G.S.	Chalk, "Upper Greensand," Hastings Sands, Purbecks, Portland Stone and Sand, Kimmeridge Clay, Corallian Series, Oxford Clay.
Crayford & Erith.	Prof. J. Morris, M.A., F.G.S.	Lower Brick-earths of the Thames Valley, Thanet Sands, Chalk.
Newbury.	The President. Walter Money, Esq., F.S.A.	Low-level Gravels and Peat Beds, High-level Gravels, Bagshot Series, London Clay, Woolwich and Reading Series, Chalk.
Orpington & Knockholt. (1st of Weald Series.)	J. Logan Lobley, Esq., F.G.S.	Valley Gravels, Thanet Sands, Chalk.
Watford.	Wm. Whitaker, Esq., B.A., F.G.S. John Hopkinson, Esq., F.G.S., F.L.S.	Terrace Gravel, Drifts, Reading Beds, Chalk.
Knockholt & Sevenoaks. (2nd of Weald Series.)	J. Logan Lobley, Esq., F.G.S.	Chalk, Gault, Folkestone Beds, Hythe Beds (Kentish Rag).
Bath.	Charles Moore, Esq., F.G.S.	Westbury Iron Ore (Corallian), Inferior Oolite, Lias, Rhætic, Carboniferous Limestone.
Sevenoaks & Tunbridge. (3rd of Weald Series.)	J. Logan Lobley, Esq., F.G.S.	Gault, Folkestone Beds, Hythe Beds.
Tonbridge & Tunbridge Wells. (4th of Weald Series.)	J. Logan Lobley, Esq., F.G.S.	Weald Clay, Tunbridge-Wells Sands, Wadhurst Clays, Ashdown Sands.

LOCALITIES.	DIRECTORS.	PRINCIPAL FORMATIONS.
Tunbridge Wells & Crowborough Beacon. (5th of Weald Series.)	J. Logan Lobley, Esq., F.G.S.	The same subdivisions of the Wealden formation.
Ledbury.	G. H. Piper, Esq., F.G.S. Dr. Chas. Callaway, M.A., F.G.S. Dr. Hicks, F.G.S.	Old Red Sandstone. Upper Silurian: Upper Ludlow; Aymestry Limestone; Lower Ludlow; Wenlock Limestone and Shale, Woolhope Limestone Upper Llandovery Sandstone and Conglomerate, Hollybush Sandstone, Crystalline and Eruptive Rocks.

The thanks of the Association are due to the following for assistance and hospitality at the Excursions:—The Marquis of Abergavenny; G. H. Piper, Esq., F.G.S.; Chas. Callaway, D.Sc., F.G.S.; Mrs. Devas; and the Members of the Malvern Field Club.

Your Committee have endeavoured by the addition of a few simple diagrammatic illustrations to render the programme of the Excursions as instructive as possible; and the thanks of the Association are due to the various Directors for their readiness in supplying all necessary information on matters connected with the organisation of the Excursions.

The Meetings were well attended during the year.

The Address by the President at the opening of the Session, 1879-80, attracted an unusually large audience, and was listened to with much interest and attention, filled as it was with geological facts of the greatest importance.

The following Papers were read:—

On the British Eocenes and their Deposition, by J. S. Gardner, Esq., F.G.S.

On the Insect Fauna of the Palæozoic Period, and the British and Foreign Formations of that Period in which Insect Remains have been detected, by H. Goss, Esq., F.G.S., F.L.S.

On the Gault, by F. G. H. PRICE, Esq., F.G.S.

On the Fossil Corals obtained from the Oolite of the Railway-Cuttings near Hook Norton, Oxfordshire, by R. F. TOMES, Esq., F.G.S.

Notes on the Rev. J. F. Blake's Paper on the Chalk of Yorkshire, by Dr. CHAS. BARROIS, and reply by the Rev J. F. BLAKE, F.G.S.

On the Dinosauria, by Prof. G. H. SEELEY, F.R.S., F.G.S.

On the Age of the Principal Mountain Ranges of the Globe, by J. LOGAN LOBLEY, Esq., F.G.S.

On the Nature and Origin of Peat-bogs, by the PRESIDENT.

On Geology and its Uses (Address), by the PRESIDENT.

On the Origin and Petrology (specially of South Side) of Salisbury Crags, Edinburgh, by ANDREW TAYLOR, Esq., F.C.S.

Your thanks are still due to the Council of University College, for the continuance of their liberality in granting us the use of their spacious Library for our Monthly Meetings.

Your thanks are also due to the Quekett Microscopical Club, for the use of their lamps at our Annual Meetings.

Your Committee have much pleasure in recommending for election as Honorary Member of this Association Prof. W. H. Flower, LL.D., F.R.S., Conservator of the Hunterian Museum, and President of the Zoological Society, so well known by his important contributions to the Comparative Anatomy of the Mammalia, and more especially by his memoirs on the Cetacea. His lectures on Fossil Mammalia were an important contribution to geological science; but the Members of this Association are particularly indebted to him for many instructive demonstrations on subjects of geological interest from the admirable collections in the Hunterian Museum.

(*For Balance Sheet, see page* 309.)

The Report of the General Committee was unanimously adopted as the Annual Report for the year 1879.

The ballot having been completed, the President announced that the following had been elected:—

GENERAL COMMITTEE AND OFFICERS.

PRESIDENT.

Professor T. Rupert Jones, F.R.S., F.G.S., &c.

VICE-PRESIDENTS.

Rev. J. F. Blake, M.A., F.G.S.

Henry Hicks, Esq., M.D., F.G.S.

Wilfrid H. Hudleston, Esq., M.A., F.G.S., F.C.S.

Prof. John Morris, M.A., F.G.S., &c.

TREASURER.

F. G. Hilton Price, Esq., F.G.S., F.R.G.S., M.A.I.

SECRETARY.

John Foulerton, Esq., M.D., F.G.S.

EDITOR.

J. Logan Lobley, Esq., F.G.S., F.R.G.S.

LIBRARIAN.

Bernard B. Woodward, Esq.

William Carruthers, Esq., F.R.S., F.L.S., F.G.S.

H. G. Fordham, Esq., F.G.S.

J. S. Gardner, Esq., F.G.S.

H. Goss, Esq., F.G.S., F.L.S.

John Hopkinson, Esq., F.L.S., F.G.S., F.R.M.S.

Charles J. A. Meÿer, Esq., F.G.S.

Wm. Murray, Esq., F.R.G.S., M.R.I.

James Parker, Esq., F.G.S.

F. W. Rudler, Esq., F.G.S., M.A.I.

E. Swain, Esq., F.G.S.

Henry Woodward, Esq., LL.D., F.R.S., F.G.S., &c.

T. J. Young, Esq., F.G.S.

The thanks of the Association having been unanimously given to the retiring Officers and Members of Committee for their services during the past year, the proceedings of the Annual General Meeting then terminated.

BALANCE SHEET OF THE ASSOCIATION

For the Year ending December 31st, 1879.

Dr.

		£	s.	d.
To Balance, January 1st, 1879		74	14	6
,, Sale of Publications		4	0	4
,, January and July Dividends on £340 17s. 8d. *Consols*		10	0	4
,, Life Compositions		40	10	0
,, Entrance Fees	£11 0 0			
,, Annual Subscriptions	£118 13 6	129	13	6
		£258	18	8

1880.—January 1. To Balance in hand ... £40 3 0

Cr.

	£	s.	d.
By Printing and Illustrating "Proceedings"*	112	8	5
,, Miscellaneous Printing, including the Library Catalogue, Report, and Circulars with Illustrations	42	12	5
,, Library	4	1	0
,, Fire Insurance up to 25th Dec., 1880... ...	1	17	6
,, Postage and Addressing	34	14	8
,, Stationery	1	19	11
,, Gas, Attendance, and Miscellaneous Items	21	1	9
Balance brought forward	40	3	0
	£258	18	8

Examined and found correct,
H. GOSS, } Auditors.
H. M. KLASSEN, }

University College, London,
Jan. 31, 1880.

J. FOULERTON, M.D.,
Sec.

* It should be mentioned that for illustrations only £1 of this amount was paid by the Association; the respective authors of the papers in Vol. V., Nos. 7 and 8, and Vol. VI., Nos. 1, 2, 3, having liberally paid for illustrating them.

ORDINARY MEETING.

FEBRUARY 6th, 1880.

Professor T. RUPERT JONES, F.R.S., &c., President, in the Chair.

The Donations to the Library received since the previous meeting were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association :—

W. H. Eldridge, Esq., and R. Darell Stephens, Esq., F.G.S.

The meeting then resolved itself into a Conversazione, when various microscopical objects of geological interest were exhibited.

ORDINARY MEETING.

MARCH 5TH, 1880.

Professor T. RUPERT JONES, F.R.S., &c., President, in the Chair.

The Donations to the Library since the previous meeting were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association :—

Samuel Noble Bruce, Esq., F.R.C.S., F.PHIL.SOC. ; The Rev. George Gates, B.A., B.Sc. ; D. J. Legg, Esq. ; J. Ogle, Esq. ; F. L. Watkins, Esq. ; and J. T. Wright, Esq.

The following Papers were read :—

1. ON THE CLASSIFICATION OF ROCKS.

By the Rev. J. F. BLAKE, M.A., F.G.S.

---

2. ON THE CLASSIFICATION OF ROCKS.

By Professor G. RENEVIER.

(*Communicated by* THE PRESIDENT.)

VISIT TO THE MUSEUM OF PRACTICAL GEOLOGY, JERMYN STREET.

MARCH 13th, 1880.

Director.—F. W. RUDLER, Esq., F.G.S., Curator of the Museum.

DEMONSTRATION ON THE MINERALS IN THE HORSE-SHOE CASE.

(*Report by* W. H. HUDLESTON, Esq., M.A., F.G.S.)

The rock-forming minerals constituted the principal subject of the demonstration, which was, therefore, petrographical rather than mineralogical.

SILICA. (*Phanerocrystalline.*)

Occurs as quartz in granite, gneiss, mica schists, quartzite, sandstones, and quartz-porphyry (elvans); in the latter the crystals are perfectly developed as double six-sided pyramids of small size. The form of the crystal of quartz when free to develop is that of an hexagonal prism, which is striated transversely (distinction from other hexagonal minerals as beryl), the result of oscillatory combinations between the prism and the pyramid. A very fine crystal, recently presented by Mr. John Arthur Phillips, found in decomposing granite, is believed to be a growth *in situ* due to liberated silica, which may thus in part account for the diminished percentage of silica in the rock so decomposed. Fine rock crystals, penetrated by chlorite, tourmaline, or rutile, were pointed out, as also a smaller one with cavities containing liquid. Such cavities are due to the inclusion and condensation of vapours, and inferences as to the probable temperature and pressure under which the parent rock consolidated have been drawn from the condition of the bubble in the cavity, but as these are not constant in the same specimens the conclusion would seem to be vitiated. Quartz, as rock crystal, is eminently the κρύσταλλος (ice) of the ancients, and like all transparent minerals, except those of the tesseral system, is capable of double refraction, as is here shown by a crystal ball of this mineral. Amongst other properties it possesses a conchoidal fracture like glass, and very rarely exhibits cleavage.

The preceding remarks apply principally to the geological relations of quartz or rock crystal; its ornamental relations were briefly touched on. As regards colouring we have false topaz, cairngorm, amethyst, &c., and in catseye a peculiar fibrous structure is taken advantage of in transverse section. Then, again, there is avanturine, where scales of mica are disseminated in an intensely hard quartzite. A noble example of such a rock is the handsome vase presented by the late Emperor of Russia to Sir R. Murchison, and by him bequeathed to the Museum.

SILICA. (*Cryptocrystalline to Amorphous.*)

Amongst the chalcedonic varieties (cryptocrystalline) are onyx, sardonyx, carnelian, chrysoprase, &c.; in onyx we have white and dark layers, in sardonyx white and brown. Chalcedony may be artificially tinted in imitation of these natural colours by soaking the mineral in some saccharine solution, and then charring the sugar, or other substance rich in carbon which has been absorbed, by means of sulphuric acid. A fine blue colour may also be imparted to chalcedony by soaking it similarly in a salt of iron, and then using ferrocyanide of potassium.

The third case contains the Agates, being a collection formed by Professor Nöggerath, of Bonn. It was shown how these were due to siliceous infiltrations into the cavities of the old melaphyres. The rock whilst of a doughy consistency was blown out with bubbles of steam and other gases, when vesicles of various size and shape were formed, as on a smaller scale may be seen in bread. From the pasty movement of the rock such vesicles are often elongated or pear-shaped. Into these the silica in solution penetrated, forming layer after layer in definite arrangement.

In flint we have a mixture of amorphous with cryptocrystalline silica, the former being partly opaline and soluble in hot potash solution. Flint is distinguished by its conchoidal fracture, whilst chert is always splintery. Opaline silica contains a quantity of constitutional water and has specific gravity 2·3, that of quartz being about 2·6. The fine varieties of opal come from Hungary and Honduras only. In opalized wood we have a pseudomorph of silica after wood.

Amongst other varieties of silica in the collection are specimens of Geyserite, a siliceous deposit from hot springs; also a slab of flexible sandstone, which bends of its own weight owing to the

presence of laminæ of talc. It is a variety of Itacolumite (matrix of the Brazilian diamonds).

Silicates.

Some of the aluminous minerals of minor importance as rock constituents were first noted; the silicate of Alumina and Glucina, for instance, in its three forms—of emerald, aquamarine, and *beryl*, which latter is not unfrequent in the granitic rocks of Donegal. *Tourmaline* occurs as the black variety called schorl, in company with pink felspar and quartz, in the beautiful rock luxullianite. *Garnets* are of more frequent occurrence, forming a rock with hornblende, and also, in conjunction with the mineral Saussurite, the rock called eclogite; they occur likewise in mica schists. The mineral is a silicate of very varying composition; in some the sesquioxide base being mainly alumina, in others ferric oxide, the protoxide bases being chiefly lime, magnesia, and ferrous oxide—sometimes one and sometimes all three—the whole group being isomorphous in the tesseral system. *Topaz*, a fluo-silicate of alumina, though not a common mineral, is a constituent of the topaz-rock of Saxony, and occurs also in the granite of the Mourne mountains.

Olivine, a silicate of magnesia and ferrous oxide, occurs in lavas and basalts, and also in the rock called Lherzolite. Under certain conditions it appears largely capable of hydration, losing at the same time much of its iron, and in this way many serpentines are produced. Of precious olivine, or peridot, some fine cut specimens were pointed out.

The *felspars* follow next in the arrangement adopted, one group belonging to the oblique, the other to the doubly oblique system of crystallization. The first is orthoclastic, with the two principal cleavages at right angles—the one parallel to the base, the other to the clinopinacoid; in the doubly oblique system the angle is either more or less than 90°, and these are termed plagioclase felspars. Potash felspar belongs for the most part to the orthoclase group, and is a very abundant constituent of granites, &c.; flesh-colour to white, often in twins as in the Carlsbad granite. There are some splendid crystals of Amazon-stone, a green potash felspar, belonging to the species called microcline, which has recently been shown to be doubly oblique. Orthoclase in large crystals is a constituent of porphyries. The basic felspars are all plagioclastic,

and labradorite, one of the most common, is usually associated with augitic minerals, and is a lime-soda felspar; whilst oligoclase may be deemed a soda-lime felspar. Attention was drawn to perthite, which consists of alternations of orthoclase and albite (soda felspar) in a sort of banded arrangement.

Next to the felspars as rock-forming minerals come the *Micas*, of which there are several species, such as muscovite, phlogopite, biotite, &c.; optically and crystallographically they divide into two groups, of which the hexagonal micas are nearly uniaxial, the rhombic micas widely biaxial.

Leucite is a volcanic mineral of the tesseral system, interesting as the first substance in the mineral kingdom which yielded potash, previously considered to belong entirely to the vegetable world. By decomposition it yields kaolin.

Jade, unimportant as a rock-former, though interesting owing to recent discussions, may be looked upon as a variety of hornblende allied to tremolite and actinolite.

Hornblende and *Augite* are bisilicates, chiefly of protoxide bases, the alumina where present being viewed as replacing silica, though this is not quite clear. No very great difference is shown in their chemical composition, and the difference in crystallization has by some been assigned to the rate of cooling, hornblende being the result of slow, augite of more rapid cooling. They both crystallize in the monoclinic system (oblique), but in hornblende the angle of the prism is 124° 30′, in augite 87° 5′. This is of importance in microscopic sections where the prismatic cleavages are shown; moreover, hornblende is strongly dichroic, augite feebly so. As a rule hornblende is associated with the more highly silicated felspars, augite with those having a lower percentage and with no free quartz. That beautiful rock orbicular diorite (Napoleonite) would seem to form an exception, as here hornblende is associated with anorthite occurring in well defined nodular forms, along with a little free quartz.

Hydrous Silicates.

Serpentine may be regarded as much in the light of a mineral as of a rock, and different varieties have received many names, such as picrolite for a fibrous variety. The lecturer entered a protest against too many names in mineralogy and petrology.

Kaolinite in its purest form is a hydrated silicate of alumina

occurring in six-sided scales, and there are various degrees from pure China Clay to impure earths.* A substance called Carclazite is a partially kaolinized granite. The orthoclase loses potash removed as carbonate or as fluoride, and silica to reappear in the form of opaline silica or rock crystal as previously indicated.

Zeolites.—These are hydrated silicates formed for the most part in the cavities of igneous rocks. The lecturer briefly commented on the magnificent series from the western Ghauts of India.

OTHER COMMON MINERALS.

Omitting the diamond from this category, we have *graphite* in graphitic schists. Of *coals* anthracite contains the most carbon, next in order comes the semi-bituminous or steam coal, and lastly bituminous or house coal rich in hydrocarbon gases. These varieties may be noted in the South Wales basin as one passes from west to east. Cannel presents no trace of its direct vegetable origin. Lignite is, in structure and composition, a nearer approach to wood, and jet is a variety of lignite. A carbonaceous product called "hatchettine" is remarkable as being associated with needles of millerite (nickel sulphide).

Of the saline minerals *Rock Salt* in England occurs principally in the Trias, but in Poland in Tertiary deposits.

Borax is now principally obtained by reaction between sodium carbonate and the Boracic acid which occurs so plentifully in the vapours of the hot lagoons of Tuscany. *Carnallite*, a soluble salt of magnesium and potassium, occurs in the salt mines at Stassfurth, where the very bitter compound was formerly thrown away as refuse. Its richness in potash and consequent value was subsequently discovered. It is of much geological interest to note its occurrence in the upper part of the salt formation and above the main mass of rock salt, which latter, being less soluble, was deposited earlier from the mother liquor.

CALCIUM MINERALS.

The sulphate occurs in a massive granular form as alabaster, not to be confounded with a stalagmitic variety of the carbonate so

* Doubts have recently been thrown upon this view of the decomposition products of felspar. It is even suggested that the hexogonal scales of the supposed *kaolinite* are due to remnants of a micaceous mineral, and that *koalin* has no right to rank as a mineral with a definite crystallographic structure.

named; gypsum and satin spar may be deemed finer varieties; and *selenite* is the definite crystalline form, of frequent occurrence in clays. The above are hydrous sulphates; anhydrite is without water, and less important geologically. The carbonate is very abundant in nature as *calcite*, of which some 800 different forms are enumerated. The general symmetry is six-sided with rhombohedral cleavage, the transparent varieties passing under the name of Iceland-spar, which is remarkable for the clearness with which it exhibits the phenomenon of double refraction. Marble is a compact variety, and some noteworthy marbles were pointed out, such as the "fire marble" obtained from a hard fossiliferous limestone found in a lead mine in Carinthia. Carbonate of lime is dimorphous, appearing in another crystalline system as arragonite (prismatic), which has probably been precipitated from waters having a high temperature.

The other Calcium minerals were briefly mentioned, and the demonstration terminated with the Fluor spars.

EXCURSION TO THE HAMPSHIRE COAST.

Easter Monday, March 29th, and Following Day.

Director:—J. Starkie Gardner, Esq., F.G.S.

(*Report by* Mr. Gardner.)

The head-quarters of the Association were fixed at Bournemouth, and Members not arriving until Monday were indebted to Mr. Swain for procuring rooms, etc. A large number arrived during the previous week, and were able to explore the Fresh-water series to the west of Bournemouth, which could not be visited on the Monday or Tuesday. An excavation opened a few days previously by Professor Morris, Dr. Hy. Woodward, Prof. Corfield and Mr. Birch, yielding fine leaves, was visited by Dr. John Evans, Prof. McKenny Hughes, Mr. Warrington Smyth, Prof. Bonney, and many Members of the Association.

First Day.—The Members and visitors, between 60 and 70 in number, met together at Bournemouth pier and proceeded along the shore towards Boscombe. On the way the Director pointed out the position of the Bournemouth series in the Eocene

formation, and the chief geological features of the coast. Far to the west, and close to Poole harbour, could be seen the cliffs which contain a rich dicotyledonous flora, shed apparently from forest trees which clothed the hilly slopes of the right bank of the Eocene river. This flora, or rather series of floras, differ remarkably from those found nearer towards Bournemouth, especially in the hitherto total absence of remains of palm. The central ranges of cliffs are almost unfossiliferous, and from their confused bedding are conjectured to present a transverse section of the silting up of the old river channel. From the pier for nearly a mile, the eastern series of leaf-beds extends, containing the remains of a very much more tropical-looking flora, probably derived from the low-lying shores of the left bank of the river. Among the palms, which are very abundant, such genera as *Phœnix*, *Calamus*, *Iriartea*, *Sabal*, etc., are conspicuous, and among the ferns, some scarcely differing from such magnificently tropical forms as *Osmunda javanica* and *Chrysodium aureum*, *Gleichenia dichotoma*, *Lygodim dichotomum*, etc. Beyond these cliffs, skirting the nearly vertical Chalk downs, are the Lower Bagshot Beds, in which the well-known leaf-beds of Alum and Studland Bays are situated, invisible on Monday through the haze, and beneath these the Lower Tertiaries. Only the upper part of the Bournemouth Fresh-water series which are estimated to be 400 ft. thick, was actually passed on Monday. The broken angulated blocks, imbedded in sand, whence come *Aroids* and a representative of *Araucaria Cunninghami*, not met with higher in the series, were pointed out. Within a few hundred yards the Fresh-water series, with its white clays, sharp quartzose sands, and entire absence of flint, became replaced by the Marine series. Owing to the absence of any slips, and the consequent inaccessibility of most of the beds, few fossils could be obtained, although indistinct leaf impressions of the reticulated fern-fronds, which immediately underlie the marine beds, were seen.

The passage of Marine to Fresh-water beds at this point was pointed out. The marine beds are stiff liver-coloured clays, becoming black on exposure to the air, containing casts of several genera of Bryozoa and Crustacea, and greenish sandy clay with casts of Bracklesham molluscs. They are highly charged with lignitic matter, and contain in places very perfect fruits, and much teredo-bored wood. Overlying them are the clean white sands, with flint shingle-beds of the Boscombe series, and above these a

thick capping of angular quaternary gravel. The Eocene shingle-beds consist of perfectly rounded flints, showing the existence, at the time they were deposited, of a heavy surf. In many cases the condition of the silex is changed, and appears a soft, chalk-like mass. Pebbles are met with in every stage of the change, wholly converted, with black flint nucleus, half converted, or merely with a thickened white coat. The process and nature of the change gave rise to much discussion. The party were here met by Dr. Allman, President of the Linnæan Society, and Mr. Pike, owner of the vast china-clay pits near Corfe Castle. Nearing Boscombe, the positions of the various fruit-beds were pointed out, and the curious tubular borings of annelids filled with horizontally-arranged lignitic matter or with fine sand, which, in places riddle the dark clays. At the corner of Boscombe Chine, instances of the denuding power of wind were seen, and in the extraordinary Honeycombe Chines, that of springs in rapidly excavating deep *cirques* in the soft strata. The zone of *Nipadites* was well seen, the empty husks floated out to sea, and now filled with sand, being in places crowded together. At another spot fragments of proteaceous or myricaceous leaves were found.

The party then proceeded somewhat rapidly to Hengistbury Head, a distance of about four miles. On the way it became apparent that, as the Fresh-water beds present a transverse section across a vast river-channel, so the Marine beds present a section through a great Eocene beach or sandbank, behind which lay a stagnant lagoon. The shingle in them became larger and larger towards the east, their well-rolled appearance indicating the distance they had travelled. Attention was called to their resemblance to the so-called Upper Bagshots of the London Basin.

The principal features of the Head-land itself were fully described in the "Quarterly Journal of the Geological Society" for May, 1879, p. 213, and the divisions were clearly made out. Having skirted it along the shore, the party mounted to the top over the *débris* of the old quarries, and after enjoying the magnificent view, quickly made their way through the heather, past the prehistoric double ramparts and ditch, to the ferry over the Stour and Avon, and thence to Christchurch. Mr. George H. Birch, F.R.S., B.A., who had travelled from London for the purpose, gave, in the failing light, an able and only too brief sketch of the history of the ancient and striking Priory Church. The

Members then returned by rail to Bournemouth, and dined together at the Criterion Restaurant.

Second Day (Tuesday.)—The party proceeded by rail to Christchurch, when the fine Norman house attracted attention, and the church was again examined while waiting for conveyances. The different building stones used were pointed out by Mr. Birch, these included Hengistbury ironstone for the foundations, and Bembridge, Binstead, Headon, Portland, Purbeck and Caen limestones for the edifice. The Members then drove to Mudeford, and thence found their way along the base of the cliffs to Highcliff. The new channel recently created by the Stour and Avon for a mile along the base of these cliffs caused much surprise when the rapidity with which it had been formed became known. The thin Nummulite bed, which is considered by the Rev. O. Fisher to divide the Bracklesham and Barton Series, could not be found in the short time at disposal, owing to the cliff under Highcliff Castle having been sloped and drained. The main features of the coast were, however, pointed out, the sequence of the beds from Hengistbury to Highcliff, the Barton Clays and Sands, the Upper Bagshots and Headon Beds of Hordle. During the short halt for lunch, Prof. Morris favoured a number of the party with an eloquent address, in which he clearly pointed out the sequence and chief characteristics of the beds and their correlation with the Eocenes of Europe, and briefly sketched, in eulogistic terms, the work of those whose labours have made it possible to trace the history of their deposition.

Dr. Henry Woodward and Prof. Bonney and the Director, having also made a few remarks, the party dispersed to collect the well-known Barton shells, which usually lay exposed in thousands upon the slopes of the cliffs, and notwithstanding the dryness of the weather being unfavourable, many beautiful specimens of the characteristic shells and teeth were obtained. Beyond Chuton Bunny most of the party again came together. Owing, however, to the shingly character of the beach, and time pressing, a large number soon after chose the coast path, and viewed the Hordle part of the series from above. Lord Justice Thesiger, of Hordle House, wrote to express his regret at being unable to join the excursion. During a short halt, when Dr. Foulerton kindly proposed a vote of thanks to the Director, the magnificent panorama which stretched for 50 miles, embracing the Isle of Wight, the Solent

and the whole coast to St. Alban's Head, and the Purbeck Hills, was fully appreciated. The Members soon after entered the conveyances provided for them at Milford, and drove to Lymington. The 5.50 train to London took the party to Brockenhurst, where a number left it to return to Bournemouth. The Excursion, was largely attended, and owing to the magnificent weather and the beauty and interest of the country traversed, was keenly enjoyed.

ORDINARY MEETING.

APRIL 2ND, 1880.

WILFRID H. HUDLESTON, Esq., M.A., F.G.S., Vice-President, in the Chair.

The Donations to the Library received since the previous Meeting were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association :—

C. Gardiner, Esq.; Alexander H. Singleton, Esq.; Walter Smith, Esq., and Miss Gertrude M. Woodward.

The following Paper was read :—

ON THE PSAMMOLITHIC FORMATIONS COMPRISING THE FORMATIONS BETWEEN THE KIMMERIDGE CLAY AND THE GAULT.

By Professor H. GOVIER SEELEY, F.R.S., &c.

Fig 1.

Fig. 2.

Fig. 3.

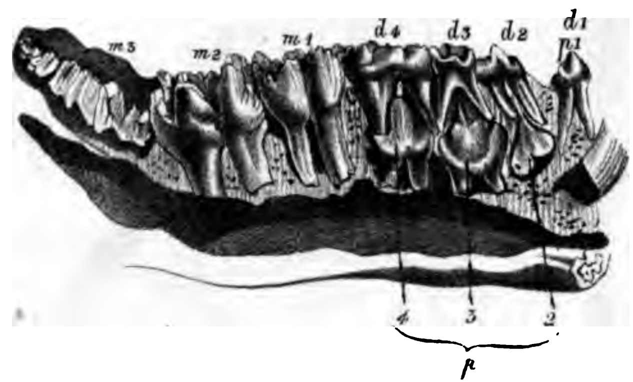


Fig. 4.

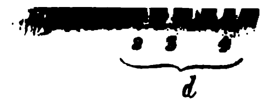


Fig. 5.

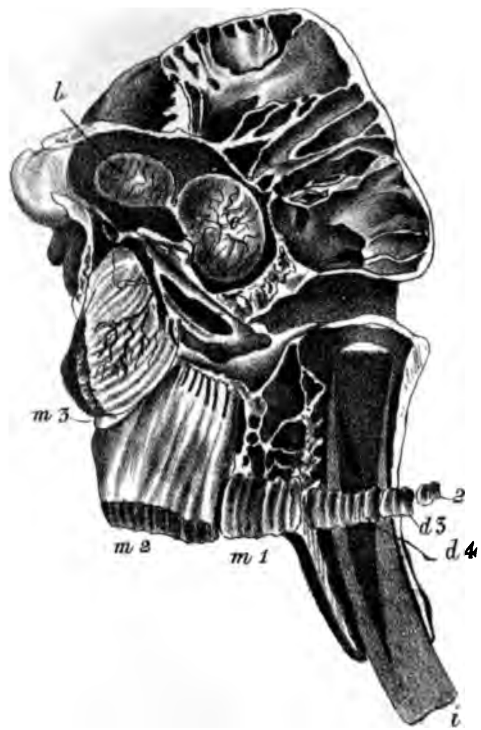


Fig. 6.

Fig. 7.

R. O. del.

VISIT TO THE BRITISH MUSEUM.

SATURDAY, APRIL 10TH, 1880.

Director:—PROFESSOR RICHARD OWEN, C.B., F.R.S., &c., Hon. Member of the Geologists' Association.

DEMONSTRATION ON THE ELEPHANTINE MAMMALS.

(*Report by* PROF. OWEN.)

On this reception of the Association at the British Museum, Prof. Owen confined his observations to specimens in the North Gallery, No. 1, and here chiefly to the fossil remains of the Elephantine Mammals.

He called attention to the large proportion of the contents of this Gallery occupied by fossils of huge *Mammalia*, and contrasted the numerical proportion of the Proboscidian ones with those of other orders of Mammals. The contrast was, perhaps, more striking in relation to their respective ranges in geographical distribution.

The giant of the Marsupial order was represented, as far as known, by a single species (*Diprotodon australis*), and this was limited to Australia. The *Megatherioids* and *Glyptodons*—giants respectively in the families of the Sloths and Armadillos—were confined to America. The species of each of these extinct families, nevertheless, had failed to attain the bulk of the majority of the elephant kind. A more remarkable character, perhaps, of the *Proboscidia* was their cosmopolitanism. Their remains have been found throughout a wide latitudinal range of both Europe and Asia; species now extinct once roamed over both South and North America. An elephant still exists in every latitude of the African Continent; another existing species is limited to the warmer latitudes of Asia and some contiguous islands. The traveller, Count Strzelecki, brought me from Australia an elephantine molar, which he stated he had received from a native, who informed him that it was from a cavern in that continent; but notwithstanding the number of fossil remains which have reached me from caves and drift deposits in numerous localities of Australasia, I have not yet got confirmatory evidence of the Australian Proboscidian.

Prof. Owen then proceeded to point out the characters of different kinds of elephantine quadrupeds. In the cabinet appropriated to the fossil evidences of such from British localities, three species, at least, had roamed, most probably at different epochs, over the land now forming our sea-girt country. Almost every county of England has contributed its evidences of these huge tenants of its original wild forest tracts.

The least incomplete evidence of an individual mammoth in the British Museum was the skull and tusks, obtained from fresh-water deposits, forming brick earth, in the Thames Valley, at Ilford, Essex. It is probable that the entire skeleton was there, for before notice of it reached the British Museum the workmen had broken the bones they came upon week after week and carried them off in bags-full to sell at an "old bone shop." When they came upon the tusks the overseer interfered, and sent notice of the "find" to the British Museum, whereupon the proper steps were taken to secure the specimen. Ivory, after ages of deposit in moist earth, loses its gelatine, and crumbles away at almost a touch. Before any part of this specimen was disturbed it was thoroughly drenched by a solution of glue in hot water. The quantity used was enormous. One of the tusks of this skull was estimated to have absorbed three gallons of the solution. Toughness and tenacity being thus restored, the parts were carefully exhumed, and form the conspicuous specimen to which the attention of the Association was invited. By its side are photographs of the entire skeleton of the mammoth lately restored and articulated from a similar Post-Pliocene deposit in Belgium. Besides the mammoth (*El. primigenius*), other kinds—*e.g.*, *El. antiquus*, Falconer; *El. priscus*, Goldfuss; and *E. meridionalis*, Nesti—were pointed out from British localities. From other parts of the world such fossils exhibited more numerous and striking specific and generic departures from the typical characters of the Proboscidian group, if the existing or more recently extinct species be taken as exemplifying them.

The most numerous and obvious examples of the range of modification are afforded by the grinding teeth. The essential character of these is their massive proportions and the presence of prominent enamelled ridges crossing the crown of the molar transversely.

These ridges may be two, or two and a half, or, at most, three, in number, as in the Miocene Dinothere; they may be three, or

four, or four and a half in number, as in the North American Mastodon; they may be ten in number, as in the *Mastodon elephantoides* of Clift and the *Elephas ganesa* of Cautley. From this the cross ridges of enamel increase in number to thirty (see last lower molar of *Elephas indicus*, Pl. II, Fig. 1). As the ridges increase in number they decrease in thickness and increase in depth, and their coat of cement increases in thickness. In *Dinotherium* and *Mastodon ohioticus* the cement can only be detected, after emergence and use of the molar crown, at the bottom of the interspace of the few and thick ridges, and at the base of the crown. As the ridges narrow, the cement rises, as it were, and finally occupies such proportion of the intervals as to constitute in the worn grinder a third distinct constituent of the triturating surface. The second constituent is exposed by abrasion of the outer coat of enamel which invests the body or true dentinal part of each transverse ridge.

Notwithstanding this extreme range of diversity of grinding surface, the molars are developed agreeably with one fundamental type, and the homology of each tooth is determinable and demonstrable by a symbol.

Two of the three anterior grinders first developed in *Dinotherium* answer to the so-called "milk-molars" in Man, and are signified by the same symbols—*d*3, *d*4 (Pl. II, fig. 2). They are displaced in *Dinotherium* vertically by two molars, which answer to the two called "bicuspids" in man, symbolised as *p*3, *p*4 (*ib.*). They answer, in fact, to the last two of the four pre-molars in the pig (Pl. II, fig. 3). Behind these rises a molar with three transverse ridges (Pl. II, fig. 2, *m*1). It is reckoned the first of the "true molars," though, in truth, it is a successor rather, and essentially a backward continuation, of the first (milk or deciduous) series of teeth : it is symbolised as *m*1. The next molar in backward position and succession, *m*2 (*ib.*), has but two transverse ridges and a basal bit of the third or "talon." Such, likewise, is the structure of the third and last molar, *m*3 (*ib.*), in *Dinotherium*.

When we pass to the Mastodon type, we find, again, that six grinders succeed each other from before backwards. In the North American Mastodon (*M. ohioticus*) you may see that the first is small (*d*2), with two coronal elevations, and the hinder one only rises as a distinct transverse ridge. The second molar, *d*3, has two

transverse ridges; the third, *d*4, has three ridges; so likewise has the fourth, *m*1, and the fifth, *m*2; but the sixth and last, especially in the lower jaw, shows four transverse ridges and a basal talon. That the second, *d*3, and the third, *d*4, of these molar teeth answered to the two deciduous teeth so symbolised in *Dinotherium* received welcome probability, if not proof, by the discovery in the *Mastodon longirostris* of the Epplesheim Miocene that one of these teeth had a vertical successor, thus demonstrating the deciduous nature of one, at least, of the three first developed molars. Its relative position to these indicated it as the successor to *d*3 (Pl. II, fig. 4), and its consequent homology with *p*3 developed in *Dinotherium*, fig. 2. This structure is, however, exceptional in the elephantine series, and the molar dentition consists of six teeth on each side of both upper and lower jaws, the nature or homology of which is now accepted as correctly symbolised (as in Fig. 5, Pl. II), by *d*2, *d*3, *d*4, *m*1, *m*2, and *m*3, in both upper and lower jaws. It is not to be supposed, however, that the array of grinders, as shown in Fig. 5, is ever seen at the same time in the elephant. Not more than one entire molar on each side of both jaws is in use at one time; it may be preceded by the fag end of the worn-out molar in front, and by the beginning of the larger molar behind.

The special modification of this dentition is the progressive increase in size, both in length and breadth, and in the number of the transverse plates of enamel-coated dentine, with cement-filled intervals, as the molar is situated further back in the series. As each molar successively rises, one behind the other, it displaces its predecessor longitudinally, and itself becomes worn away before giving place to the next behind, until finally the work of mastication is performed by a huge single grinder, the last (*m*3, fig. 1, Pl. II), on each side of both upper and lower jaws.

As a molar moves into use it presents a grinding surface of the three substances or "tissues"—dentine, *d*, enamel, *e*, and cement, *c*, fig. 1. The adaptation of this most complex of all dental structures is plain—at least, to a teleologist. The three several tissues have different degrees of density. In their application to the grinding down of tough nutritious vegetable substances the surface of the tooth is never worn to smoothness. The cemental tracts yield first and most, and form the hollow transverse channels; the dentinal tracts have yielded in a minor degree; the enamel ridges project to the final wearing out of the grinder.

The composite constitution of the Geologists' "grit," called from its use "mill-stone," is that which makes the elephant's "molars" truly "molary" or "mill-stoney."

To be sure, the "Mill-stone Grit" and the "tri-tissued tooth" both "pre-existed to their use;" and if the one was purposive or fore-ordained, fore-fashioned to its end, so may it be predicated of the other; only the species of animal forming the tooth could not be without it. The tooth exists in and for the elephant alone. The stone, like any other mineral, is selected and put to its use according to the needs and judgment of the selector—viz., the human builder, sculptor, or machine-maker.

The Professor next proceeded to notice another character of *Proboscidian* dentition, the first to catch the eye—viz., the pair of huge tusks, which project from the upper jaw as a rule (Pl. II, fig. 5. *i*).

These answer to a pair, probably the first or foremost of the teeth called "incisors," from their crown being modified, in most mammals, for cutting. They are kept in a fitting state for this end, in the Order of Mammals in which the large cutting incisors are most common and conspicuous, by mutual opposition and attrition of the upper and lower pairs. In the *Rodentia*, also, as in the *Proboscidia*, the formative pulp is maintained, and the chisel-teeth grow in the ratio of their wear. If a hare or rabbit has the jaw broken by a shot and escapes, the healed bone may put the upper and lower incisors "out of gear." In that case both pairs, by continuous growth, may become long, curved, projecting, and pointed tusks, like those of the elephant.

The Professor then directed the attention of the Association to the specimen which he termed the most instructive of the entire elephantine series, the skull—viz., with the lower jaw, of a *Mastodon angustidens* (Cuvier) from the Miocene formation of Sansan, France. A pair of ever-growing incisors had been developed from both upper and lower jaws, and the lower ones, being entire, showed the oblique wear through friction against the upper tusks, giving them the chisel character of the rodent incisors.

He next pointed out the rudimental pair of lower incisors in the skull of a new-born *Mastodon ohioticus*, and showed the mandible of a full-grown male of that species in which one such rudiment was retained, but required removal of part of the bone to expose the toothlet in its hidden alveolus.

As a rule, a single pair of incisors, unopposed, grows to the size and shape of formidable weapons in the elephantine group; but here, again, the retrospect into a zoology of times long past is essential to a cognizance of the range of variety in nature. In the extinct Dinothere the upper tusks abort and the lower pair is developed (Pl. II, fig. 2, *i*); in elephants proper the lower tusks abort and the upper pair developes. The latter is the incisorial character of the two sole existing species of this once numerous and widely distributed group of gigantic mammals.

The African elephant is systematically hunted, harried, and slain for the sake of its tusks. Those of the Indian elephant are equally coveted, but the accessory value of the animal, from its docility as well as power, is now exclusively availed of in the Asiatic localities. The African elephants were, however, as good servants of the Carthaginians.

The mercantile value of the tusks depends upon a peculiar microscopic modification of their dentine (for which reference was made to the "Odontography," Pl. 146, fig. 8, copied in Pl. II, fig. 6). True ivory may be detected by the naked eye, any transverse section or fracture showing minute lozenge-shaped markings due to opposite decussating curved lines. A great proportion of ivory used by the cutlers and other trades in the North of England is or was derived from neither of the existing kinds of elephants, but from the extinct species which roamed over the northern latitudes of Asia and Europe, the *Elephas primigenius* of Blumenbach. The natives of such Asiatic latitudes, Tungusians and others, have occupied themselves for centuries in collecting the semi-fossil tusks of this species, which are bought by Russian merchants and exported for sale.

In one of such quests a Tungusian detected a pair of tusks projecting from a vertical cliff too high for his reach, at the mouth of the Siberian river Lena. He revisited the locality, and found one summer that a mass of the cliff had fallen with the entire carcase of the mammoth to which the tusks belonged. Mr. Adam, an English resident at St. Petersburg, secured for that capital the skeleton and skin. The animal had a double clothing, the under one of thick curly wool, which was covered and concealed by a coat of long blackish hair. (Some of the latter was exhibited.) Subsequently entire mammoths have been discovered in an upright position in banks of the river Alassejah, in the Obi

peninsula. A thick coat of mud had protected the carcase from the decomposing influence of the atmosphere, and subsequent congelation preserved it, until recent exhumation. Such well-clad elephants would migrate, like their contemporaries the musk-oxen (still existing in American polar regions), northward during the short nightless summer, as far as the 70th degree of latitude, where hardy shrubs push out a tempting but short-lived foliage. Thence the mammoths retreated southward in the long winter season.

The chief condition of the existence of elephantine species is the extent of tree-clothed earth. The advent of man and his clearance of forests may have been one of the conditions of limitation of the geographical ranges of the Proboscidians.

The Professor next adverted to the origin of this peculiar form in the Mammalian Class and its affinities therein. Zoologists who make the deciduous appendage of the fœtus a guide have placed the elephants, some with the unguiculate carnivores, others with the ungulate hyracoids, the placenta being annular or zonarial in both these groups. Those who prefer the indications of cerebral structure deem the elephants to be essentially inferior to both the ungulate and, unguiculate *Gyrencephala*. The brain-character indicated by that term is not, however, a convolutional one, but such relative size of the cerebrum as makes it cover part of the cerebellum. The cerebrum may be smooth, though relatively large, as in some small monkeys, and the cerebrum may be convoluted although relatively small, as in the low monotrematous Echidna. In the elephant the cerebrum is wholly anterior to the cerebellum. The brain-case in sections of the skull, which were pointed out, shows the position of the cerebrum (*c*, fig. 5, Pl. II) to be wholly in advance of the cerebellum, *b*. Now, this is essentially the brain character of the *Lissencephala*, in which, as a rule, the cerebral surface is unconvolute; and with this group of mammals the Professor stated that he regarded the elephant to be affined, although its cerebrum had many convolutions. In the Lissencephalous sub-class the *Rodentia* present the most numerous marks of affinity to the *Proboscidia*. The correspondence in regard to the ever-growing incisors had been alluded to, and the older the Proboscidian, and nearer in time to any hypothetical common ancestor, the closer become that correspondence, as had been pointed out in the specimen of the Miocene

Elephas angustidens. Reciprocally the closest correspondence, in complexity of structure and relative size of the molar teeth with the elephants was to be found in the Rodent Order. The Professor again referred to the "Odontography" (p. 403, Pl. 105, fig. 17). The structure of the grinders in our common water-vole (*Arvicota*) recalls the structure of those in the African elephant and many Mastodons. That of the grinders of the Capybara (*Hydrochoerus*, Pl. II, fig. 7), has a close resemblance to that in the Asiatic elephant. Moreover the restricted number of premolars characterises both groups. The *Leporidæ*, like the *Dinotheria*, show, exceptionally, three milk-teeth, which are pushed out by premolars; but the majority of Rodants develope but one premolar, as in *Mastodon*. Again, the presence of the five digits and the absence of true hoofs in the elephants supplement the dental affinities to the Rodentia. In the Capybara, at least, the claw of each digit presents as near an approach to the hoof as in the foot of the elephant.

But how about the character of size? Can we venture, with the deep-thinking Robert Ed. Grant, to call the elephant a "gigantic mouse"? This would be a fair though seemingly exaggerated expression of its true affinities; and the Capybara, with its great grinders and their many transverse ridges of enamel, *e*, dentine, *d*, and cement, *c*, is the largest among the existing *Rodentia*. But as we grope about the dimmer regions of the past, we come upon unequivocal Rodents of greater bulk—the *Trogontherium Ohioense*, *e.g.*, attained the length of six feet. Are there, it may be asked, extinct Proboscidians which supplemented the Mastodontal evidence of "*dentes scalprarii*" by manifesting elephantine modifications on a diminutive scale? Hereupon the Professor drew the attention of the Association to the case devoted to the interesting fossils of the dwarf elephants from the Zebbug Cave in the Isle of Malta (*Elephas melitensis*).

The discourse concluded with an account of the discovery by Capt. Cautly, in a sandstone quarry, of the petrified remains of his *Elephas ganesa*, and of the way in which the skull with the tusks, ten feet in length, had been worked out of the blocks blasted from the quarry, 1,000 feet above the sea level, in the Sewalik Hills, after these blocks had been received at the British Museum.

EXCURSION TO CAMBERLEY.

APRIL 24TH, 1880.

Directors:—The PRESIDENT; the Rev. A. IRVING, B.A., B.Sc., F.G.S.; and Captain C. COOPER KING, R.M.A., F.G.S.

(*Report by* THE DIRECTORS.)

Some thirty members of the Association, coming from London by way of Woking, were met at the Camberley Station, by the President and some friends. In the first place the party examined maps and geological sections of the district, at the President's house, and also archæological maps and diagrams relating to the Roman Road and British Camp, which would be seen in the course of the day. A collection of stone implements (partly contributed by Captain C. C. King), and some geological specimens, illustrative of local geology, were also looked at.

A start was soon made for the Flint-implement Station, near the Staff College, on the confines of Surrey and Berks. On arriving at the lateral *cul-de-sac* of the Wishmoor Valley, in which the flint station is situated, Captain C. C. King pointed out that, from its shape, and from the line of gravel which lies at an almost regular level along the sides of the existing hills, the area seems to have been at one time a lake, the western barrier of which is now represented by a small hog-backed hill. This has evidently been gradually worn away by the two brooks which still exist, allowing the lacustrine waters to escape. The floor of the valley contains much silty matter, with stems of wood, resting on a thin substratum of clay, and it was in this silty sand that the flint flakes and some flint implements had been found. They are not distributed equally over the valley-bottom, but lie in definite patches. It was therefore probable that the ancient folk occupied either natural or artificial elevations in the marsh or lake. Some sections of the special spots, exposed for the purpose, displayed the sandy and silty nature of the soil with its numerous fragments of decayed woody matter and a few flakes.

Leaving this interesting lacustrine valley, the high road from London to Salisbury was crossed, and Obelisk Hill ascended. It was pointed out that the glen at its foot is continuous with some

of the ancient hollow road-tracks, whilst others pass the southern foot of this small, well-marked, conical hill. The gravel capping the summit is highly ferruginous, forming "pan," and has resisted the denuding agents which carved the numerous valleys all round out of the Post-Tertiary gravel plateau. The many-windowed, empty Obelisk, once roofed and topped with a gilt ball, was built by a family living at Hawley, two miles off on the west side of the Blackwater, who are said to have used it for making signals to friends living away to the north-east, near High Wycombe. The general structure of the country was described by the President, who briefly alluded to the Lower Tertiaries let down in the shallow syncline between the Chalk hills of Surrey and of Bucks, to their having been planed down by marine denudation, and to their coating of gravel, consisting of (1) subangular flint from the Chalk, (2) pebbles from outcrops of the lowest Tertiary beds turned up with the Chalk, (3) water-worn fragments of Neocomian chert from beyond the Guildford gap, (4) more or less worn "Sarsdens," or consolidated blocks of the Upper-Bagshot Sands, (5) numerous small pebbles of quartz, and (6) occasional masses of sand, frozen when embedded. The subsequent erosion of this Post-Tertiary plateau was referred to the action of sea-creeks and streams.

A descent into the valley on the south foot of the hill led across some of the ancient road-tracks, now much obliterated by cultivation, and to openings in the low-level gravel, here thicker than usual, as much as four or five feet, owing perhaps to the iron-topped hill having checked the downflow of winter-ice and gravel-bearing floods. Sarsdens are frequent here, mostly much water-worn: some showing traces of vertical rootlets, some with quartz-pebbles, some with flint fragments, and some showing small concretionary structure, have been met with.

On the top of Crawley (Portesbury) Hill forming the south side of this Camberley Valley, the plateau-gravel, with its over-lying loam (loess) and its ferruginous layers, is well seen in the railway-cutting. Here the gravel and loam die out in thin beds on a sloping and eroded floor of Bagshot Sand at the former head of one of the old sea-creeks.

Regaining the high-road, near Hangman's Lane, where one or more of Turpin's friends were executed, the party soon reached the "Jolly Farmer," an inn situated in the angle at the junction

of the Portsmouth and Southampton roads, and succeeding—on a different spot—the "Golden Farmer," which was on the north side of the road, and formerly associated with the nefarious doings of Dick Turpin, before the present mailcoach-road superseded the many old trackways on the heath. Going northwards the excursionists, on Penny Hill, had a beautiful view over the Bagshot Valley, with the Windsor crest-line in the distance.

A pleasant walk through the heather and pine-woods of East-hampstead Plain, and across the Wishmoor Valley, with nothing more exciting than the capture of a snake, brought the party, by Hermitage Hill, to the intersection of five forest-rides, known as "Wishmoor Cross," a name transferred from the old Hermitage *Cross* to these cross-roads. Their further progress soon led them across the old Roman Road, from ad-Pontes (Staines) to Calleva (Silchester), known as "the Devil's Highway," and "the Nine Miles Ride." Where this ancient highway is crossed by a set of forest-rides is a small grassy mound marking the place of a former gallows-stem, on which some highwaymen suffered death.

One of these forest-rides led direct to the south entrance of the old British Camp, known (like others about the country) as "Cæsar's Camp." The Rev. Alex. Irving, of Wellington College, having joined the party, here gave an account of what was known of the Camp. The name by which it is known is a misnomer. The spot may have been occupied temporarily by a Roman legion at some time or other; but its outline is of such a form as to preclude all belief in the possibility of its adaptation to the requirements of the Roman legion, which had its rules for encamping as distinctly understood as those for marching; and nothing which the site presents would suggest its having been the scene of a Roman occupation. Much better was it adapted for the rude methods of defence practised by a more primitive race; and there is every reason to believe that it was an important point of vantage to the early British tribes of the south, not so much, perhaps, in any stand they made against their Roman conquerors as in the many inter-tribal feuds which prevailed among themselves. Tools of the most primitive description would suffice for the construction of the double rampart, which now almost encircles this, one of the largest of fortified enclosures in the country. Its form is roughly elliptical, with a sinuous out-

line, so that it has been compared to an oak-leaf in form; the major axis of the ellipse, which runs north and south, is about one-third of a mile in length. The "Camp" occupies the northernmost spur of the Easthampstead Plain, near Bracknell, and, as a military position, would enable an army holding it to command a considerable portion of the Valley of the Thames. At its northern end it is capped with the usual gravels of the country, as indeed are most of the spurs of the plateau. These gravels have become in many instances so closely bound together by oxide of iron as to form the most effective protection to the soft and incoherent strata of the Bagshot country; and it is to these that the peculiar contour of the country about Wellington College is due. The conical hills of Edgbarrow and Ambarrow, and the various long lines of hills, known locally as "Ridges," owe their preservation against erosive agencies to the presence of such gravels and conglomerates.

Crossing over to the western side of the Camp, where, on the steep slope of the hill, the so-called double ditches and valla were well-defined, Captain C. C. King remarked that it seemed doubtful whether these earth-walls or valla could be looked on as successive lines of defence. Owing to the short range of the early missiles, it would be almost impossible to hold both ridges at the same time, the command of one over the other being so slight; and, further, the retreat from the outer banks into the body of the fortress would scarcely be effected by a direct run from one to the other, as such retreat might be accompanied by a rush of the enemy, entering the "Camp" perhaps with the defenders. As probably, also, the inner vallum was crowned by a wicker breastwork (which would be impervious to most of the missiles), the retreat would naturally be made by the gates, and to do this the defenders of the outer vallum would have to find their way round to these entrances, exposed to the enemy's attacks during the movement. It therefore seemed more likely that the object of the outer vallum was only to provide sufficient earth to make the inner ditch a more formidable obstacle to an assault. The Camp, from its "trace" and simplicity, was evidently British. Some fragments of Brit-Roman pottery were afterwards found in the black soil of one portion of the interior. In the Bagshot Sand, below the gravel, in the sunken way on the north side of the Camp, Capt. King discovered, by earnest search, a pretty little valve of

Lucina (?). A few of the party here left for the Bracknell Station, so as to reach London quickly.

Returning to the south side of the Camp, the party, under the guidance of the Rev. A. Irving, visited an interesting area of grassy ground, among the extensive fir-plantations, which is called "Wickham Bushes." One part is planted with oak, and is regarded as the site of a Roman town. Another portion is picturesque, with scattered old thorn-trees ; and this also yields abundant fragments of Roman and Romano-British pottery, but is regarded by some as having been the site of a British town, some of the old hut-pits being still visible.

The Rev. Mr. Irving referred to the excavations that had been made there, which had resulted in the discovery of some Roman coins and pieces of metal, but not in any quantity.

The association of the "Camp" with the name of Cæsar is no doubt due to the presumed Roman settlement or town, of which numerous traces have been found, about half a mile to the south of the Camp. The site of this, long known as "Wickham Bushes," has been lately re-explored by W. Goodchild, Esq., one of the Masters of Wellington College, who has been aided in the work of digging by some of the Sixth Form. Very numerous fragments of pottery, and many specimens of roofing tiles, both of undoubted Roman origin, have been exhumed, and a coin of the reign of Probus has been discovered. The original name of this colony has been lost, it would seem, altogether ; but everything that has come to light shows that it must have been a station of no small importance on the great road which runs from the ancient town of Silchester to the *Pontes* over the Thames. This road, into which several others from the west appear to have converged, is still distinctly visible in places. Though much older than the Roman occupation, it was, no doubt, improved by the Romans, both as to width and straightness. After the capture of Silchester by the West Saxons, the town was burnt ; and the whole district appears to have been for a time almost depopulated. The importance of the road, as a line of communication between the West and London declined from this time. To quote words of Mr. Goodchild—"Silchester had disappeared, probably the bridge at Staines was burnt down, and such traffic as went on amid the struggles of the Heptarchy got diverted up to the new town of

Rædingas, which we now call Reading, where there was communication by water with the sea for the Saxon sea-rovers. The old road was deserted and grass-grown, and fancy fixed upon its present name of 'Devil's Highway,' as upon a road that led to nowhere, and was of no use to ordinary mortals. After the conversion of the Saxons to Christianity, it was a common thing to look upon Roman remains, which up to the thirteenth century were prominent objects in many parts of England, as works of the Devil; they had been made by heathen, or at least by unsound Christians of the Irish school, so true Churchmen would do well to keep clear of them."*

Capt. C. Cooper King remarked of Wickham Bushes that, although the grassy area, dotted with ancient thorn-trees and oaks, contained much Brit-Roman pottery (a fragment of a mortarium was picked up by Major Fothergill), it does not therefore follow in the least that the settlement was formed, or even occupied by Romans. The circular hollows which dot the ground at varying intervals would seem to indicate the sites of pit-dwellings anterior to the Roman invasion; and the presence of Roman remains may only indicate that the village existed up to Roman times, and that Roman loot was brought thither from other places.

The excursionists had then to leave the plateau, and the beautiful view, comprising both the northern and the southern Chalk-hills bounding the Bagshot district, and crossing the Roman road at a point eastward of the former transit, they dipped into a narrow wooded valley, and then descended Lodge Hill, on which the Broadmoor Lunatic Convict Prison is situated. Here they saw a pit in the high-level gravel, with striking evidences of the intervention of floating ice in modifying the constituent layers of gravel, sand, and loam, during and after their deposition. For want of time the Rev. Mr. Irving could not take the party up Edgbarrow Hill, the summit of which is fortified by ferruginous "pan" (as in the case of Obelisk Hill already mentioned), and in consequence retains a conical form.

Time did not admit of an inspection of the sections exposed in the brickfields of Wellington College and in the adjoining railway cutting. The Bagshot strata are characterised here, as elsewhere

* See a lecture by W. Goodchild, Esq., M.A., of Wellington College, entitled "Fragments of Local Legend and History," published by George Bishop, Wellington College Station.

on the same horizon, by the great abundance of well-rolled pebbles of black flint, which are scattered through the sand, with the rarest possible occurrence of any material from a more distant source than the Cretaceous formations. So well defined, in fact, is this deposit that it may well serve as a basement for the Upper Bagshot Series. The railway close by cuts through these beds; and here, though they could not be walked on, being too wet with the water soaking out on the clays, the side-banks showed clear sections of this part of the formation as the hungry geologists hurried by to the well-laid refreshment-table at the Wellington Hotel close to the station.

Having fully appreciated the caterer's judicious and provident care, and having voted hearty thanks to their Directors, the Members and their friends availed themselves of a train by the South-Eastern Railway, either for Croydon (as did some) or to Blackwater (as more did), thence to walk to Camberley, either through the grounds of the Royal Military College, or by the high-road. After a farewell call at the President's house, about twenty assembled at the station to return to London by Woking, after having usefully and pleasantly spent a most delightful day among the firs and heaths of the very interesting "Bagshot District."

ORDINARY MEETING.

MAY 7TH, 1880.

W. H. HUDLESTON, Esq., M.A., F.G.S., &c., Vice-President, in the Chair.

The Donations to the Library received since the previous meeting, were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association :—

George Powie Cochrane, Esq.; Franklin J. Curst, Esq.; N. W. Holmes, Esq.; W. Hull, Esq.; Charles Mayhill, Esq.; James

N. Wheeler, Esq.; William Thomas White, Esq.; and W. A. Wickes, Esq.

The following paper was read:—

On the Geology and Physical Features of the Bagshot District.

By the President, Prof. T. Rupert Jones, F.R.S., &c.

EXCURSION TO UPNOR.

Saturday, May 8th, 1880.

Director:—William Whitaker, Esq., B.A., F.G.S., of the Geological Survey of England.

(*Report by* The Director.)

On leaving the railway at Strood, we took to the footpath up Frindsbury Hill, where a halt was made and the features of the district were explained, including the dip-slope of the Lower Greensand (seen through the gap in the Chalk ridge made by the Medway) and the tendency of the Chalk to have a small second escarpment, of which the standpoint was an example.

The large chalk quarries by the river side, on the south-east, were then visited. Here some well-marked layers of flint were noted, and also some pipey masses of irregular gravel on the Chalk, apparently the remains of a high terrace of Medway Gravel.

The walk having been continued northward, we came to the most southerly of the Upnor sections, a disused pit at the south of Tower Hill, showing the junction of the Thanet Sand and the Chalk, with the usual greenish bed and its green-coated flints.

We then went on by the side of the Medway, until, just before reaching the village of Upnor, a new section was seen in the River Drift, which here cuts across the low hill. It showed some feet of brick-earth, with gravelly layers, over gravel. Pointing across to the opposite side of the river, attention was drawn to the spot where *the largest fossil in the world* (a Dutch war-ship) had been found in the alluvium in the works of the new Chatham Extension Dockyard.

The party straggled somewhat through the village, presumably to investigate the water-supply, but was soon re-united in the first of the great Tertiary sections, which unfortunately were not in such good order as when first known to the writer when mapping the neighbourhood for the Geological Survey some years ago. In this pit the junction of the sand of the Woolwich Beds with the Thanet Sand was seen; but the clay shell-beds of the former and the overlying Oldhaven Beds and London Clay could only be got at with difficulty. From the north-east dip, however, these higher beds are brought down in the next pit, at the back of the cement-works.

In this latter pit a longer stay was made. The frequent occurrence of selenite was noticed, not only in the London Clay but also in the underlying beds. In the London Clay it often occurs here in thin sheets along joint-fissures, as well as in detached crystals or masses of crystals. In the estuarine shelly clays of the Woolwich Beds masses of crystals also occur, whilst in the intermediate Oldhaven Sand a peculiar variety is found, consisting of masses in which the fine grains of sand have been caught up between the plates of the crystals, forming, indeed, a sort of sandstone, which sometimes makes casts of the shells, and sometimes occurs in layers some feet long. This variety of the mineral has been found only in the two chief Kentish sections of the Oldhaven Sand, those of the Upnor pits, and of Reculver cliffs. A number of fossils were got here from the Oldhaven Beds; but the estuarine shells in the midst of the Woolwich Beds were mostly hidden by talus.

In the furthest pit the London Clay, with its septaria, was well seen, whilst the shelly clays of the Woolwich Beds could be worked at the floor.

A return was then made to Rochester, an advanced guard being successfully thrown forward for foraging purposes. After a good meat-tea, the visit was brought to an end by a stroll to the Norman keep of Rochester Castle, from the top of which a fine view was had.

For details of the sections seen the reader is referred to Vol. iv. of the "Geological Survey Memoirs" (1872), pp. 28, 73, 143-145, 360.

EXCURSION TO OXFORD.

WHIT-MONDAY, MAY 17TH, AND FOLLOWING DAY.

Directors—Prof. PRESTWICH, M.A., F.R.S., F.G.S., &c., and JAMES PARKER, Esq., M.A., F.G.S.

(*Report by* W. H. HUDLESTON, Esq., M.A., F.G.S.)

The party were received by the Directors about noon, when Prof. Prestwich commenced a demonstration of the palæontological collection in the University Museum, directing attention more especially to the fossils from the neighbourhood.

Amongst the Portland fossils are some very fine specimens of *Ammonites pectinatus*, a new species figured but not described by Phillips in the Geology of Oxford. In the Kimmeridge Clay of the neighbourhood *Rhynchonella inconstans* occurs sparingly towards the base, and *Exogyra virgula* is tolerably common, but *Ostrea deltoidea* is reported to be scarce. A somewhat unexpected circumstance is the occurrence of *Rynch. inconstans*, in what appears to be a Corallian matrix from the neighbourhood of Marcham.

The Oxford Museum is especially rich in the remains of the vertebrates from the various Oolitic beds of the neighbourhood, ranging from the small mammals of the Stonesfield Slate to the huge *femur* of the *Cetiosaurus* from Kirklington (the *magnum bonum* of Prof. Phillips).* The Professor alluded also to the recent discovery in the Kimmeridge Clay of *Iguanodon Prestwichii*, a new species of that peculiar genus of Dinosaurs, which had not previously been discovered in strata older than the Wealden.

After enjoying the hospitality of the Directors, the party proceeded eastwards in the direction of Shotover, under their guidance. Mr. Parker had provided for the use of the Members a very useful octavo tract, containing a map and sections of the strata south of Oxford, with explanatory text. The strata represented on the map in ascending order are—

"1. *Oxford Clay*, on which Oxford itself is situated.

"2. *Lower Calcareous Grit*, resting on the Oxford Clay, and followed by

"3. *Coral Rag*. This is in part covered by

"4. *Kimmeridge Clay*.

* Reports are given of previous Excursions in Proc. Geol. Assoc., Vol. ii., p. 243; and Vol. iv., p. 91.

"5. The *Portland Sands* (including Portland Rock) follow on the Kimmeridge Clay, on ascending Shotover Hill, and appear to some extent further eastward.

"6. The *Iron Sands*, capping Shotover Hill (east of Oxford) and Cumnor Hill (west of Oxford); attributed by some to Wealden, by others to Lower Green Sand.

"To the south-east the Kimmeridge Clay is covered by the ordinary Cretaceous Beds. The sands here are referable to ordinary *Lower Green Sands*, and these are further on covered by

"7. The *Gault* in which a few fossils are found, but only in one or two places. The *Upper Green Sand* and the *Chalk* are beyond the bounds of the map; but from every part of the district (excepting in the valley of the Thames) the long Berkshire range of Chalk-hills is a prominent feature bounding the southern horizon (highest elevation, 893 feet).

"Much of the district is covered with gravels: the Low Level Gravel, chiefly in the valleys (on the brink of this gravel Oxford is built), and the High Level Gravels, on the top of one or two hills."

Four horizontal sections were given, as follows :—

"The *first* Horizontal Section starts from the turn to Marston, about one mile due east from centre of Oxford (Carfax.)

"The surface of the clay at this point is 186 feet above sea-level. Oxford is built on a bed of (Low Level) gravel; the highest point being at Carfax, viz., 216 feet above sea-level. Taking the St. Clement's level as that of the average of the clay, the gravel appears to attain a maximum thickness of 30 feet; and that is the usual depth of the wells in the higher parts of Oxford. The main Headington Road runs due east; but a lane turns off, in a south-easterly direction, towards Shotover, just at the junction of the Oxford Clay with the Calcareous Grit.

"The section mainly follows this road. A quarry can be seen of Coral Rag, resting on the sands of the Lower Calcareous Grit; and further up, of the Kimmeridge Clay, resting on the Coral Rag. Still further, the Portland Sands are seen, resting on the Kimmeridge Clay; and in the large pit on the left the Iron Sands to all appearance are seen capping the Portland.

"The *Second* Section, across Shotover-hill, and a considerable extension of high land eastward, is taken from the Geological Survey.

"It shows the *outlying* character of the Iron Sands, which for this

reason have been associated with the ordinary Lower Green Sands, occurring some few miles to the south, and in direct relation with Gault, Upper Green Sand, and Chalk.

" The *Third* Section (also following the Survey) is one across the Cumnor Hill, drawn in the same direction. The lithological character of the sands is somewhat different; and it will be observed they rest directly on the Kimmeridge Clay. On Shotover they rest on the Portland Sands.

" The *Fourth* Section is one across a portion of the Coralline Oolite ridge, which divides the Thames Valley from that of the Ock. It does not rise to any great height.

" The height of the meadows on the bank of the Thames, in a line with the section, is 207 feet above sea-level; those on the bank of the Ock 192 feet. The highest point in this part of the ridge is on the main road, where the surface is 268 feet. The distance between the Thames and Ock at this point is a little over three miles, so that the rise of some 60 feet over so large an extent is scarcely perceptible. The section therefore exhibits the very level character of the beds."

The region traversed by the two first horizontal sections was visited on the afternoon of the first day; the third and fourth sections traverse the country visited on the second day.

The following is the vertical section in the direction of Shotover according to Mr. Parker, omitting the Lower Calcareous Grit and Oxford Clay.

	Feet.
IRON SANDS, with geodic concretions of Ironstone. Laminæ of white and coloured clays. Freshwater Shells	60
PORTLAND SANDS, with large spheroidal concretions and irregular bands of Limestone	60
KIMMERIDGE CLAY—A bed of calcareous concretions near the base	70
CORAL RAG. The top bed in some places is Oolitic and worked for Freestone. Elsewhere " raggy " and " coralline " ...	30

Since the last visit of the Association in 1874, the evidence as to the development of the Oxford Clay and underlying beds in the immediate vicinity of the City, has been carefully sifted by Prof. Prestwich, from data supplied by the boring for coal at Wytham, in 1829, and by a boring at St. Clement's for water a few years later. For reasons which it is difficult to understand, the late Prof.

Phillips assigned to the Oxford Clay here the excessive thickness of 600 ft., but Prof. Prestwich has shown that its thickness at St. Clement's, according to his interpretation of the strata passed through in the bore-hole, is 263 ft., underlain by a considerable thickness of Bathonian beds, as might be expected from their great development in the Woodstock country. The saline character of the water obtained from the bore-hole at St. Clement's induces the suspicion that possibly the Trias was reached at the moderate depth of 420ft. The clay-pits at St. Clement's are in the upper part of the Oxford Clay of this district, and many specimens of *Ammonites vertebralis* and *Gryphæa dilutata* were noted.

Proceeding along Cowley Marsh, the party ascended the slope of the Lower Calcareous Grit sands, which may sometimes be seen resting directly on the Oxford Clay. On the top of the plateau (Bullingdon Green) are numerous Coral Rag pits. The vertical sections here seem barely to attain 26ft. The highest beds of all consist of true Coral Rag, full of the prostrate branches of *Thecomilia*, and with tabular lines of *Thamnastræa* and *Isastræa*. Mammilated urchins, as *Cidaris florigemma*, and *Hemicidaris intermedia*, are not uncommon. Opinions differ as to whether this rubbly rag represents a reef *in situ* or a drift accumulation. The late Prof. Phillips inclined towards the latter view. This Rag rests upon a hard crystalline limestone series, which, in this neighbourhood, is divided by a sort of soft oolitic grit and sand, but this division can barely be recognized at Headington. The limestone series rests upon the loose sand of the Lower Calcareous Grit. There is a profusion of fine shells in these hard limestones, a monomyarian fauna somewhat prevailing. *Lima rigida*, and *L. læviuscula* are common and conspicuous.

Northwards, at the old Windmill Pits, the Coral Rag may be observed under somewhat different conditions, and further up the hill the junction with the Kimmeridge Clay is seen, but the quarry is now disused, and this very interesting section is not so fresh in consequence. One specimen of *Rhynch. inconstans* was secured from the Clay, and higher up a few small bad specimens of *Ex. virgula*. Remains of large Saurians are found from time to time. The Clay is succeeded by the Portland Beds, here consisting for the most part of sands and irregular limestone bands and concretions, in which were noted *Trigonia gibbosa*, *Cardium dissimile*, &c., &c.

The lateness of the hour precluded anything more than a hasty

glance at this part of the section. The Portland Beds are succeeded by the often discussed Shotover Iron-Sands, usually grouped as Wealden. At this spot they are not rich in fossils, but towards Wheatley (about a mile to the south) beds of *Unio*, *Cyrena*, and *Paludina* are found.

Descending the hill, the Coral Rag was again inspected in the Headington quarries (see general section at Shotover *supra*). The following is a careful and detailed section of the Headington Quarries by Mr. Blake, :—*

	ft.	in.
1. False-bedded comminuted Shell Limestone ...	16	0
2. Irregular Coral Rag with *Thecosmilia* passing into and alternating with the beds above	12	0
3. Semi-oolite Shell-bed with *Cid. florigemma*... ...	7	0
4. Pebbly bed and layers of nodules with *Am. cordatus*	0	8
5. Sands of the Lower Calcareous Grit		

In this section No. 2 represents the Coral Rag passing upwards into a building stone (such as has been much used at Oxford in former years) ; whilst it rests upon a hard-bedded semi-oolitic limestone, No. 3, full of large shells, as *Ammonites plicatilis*, *Phasianella striata*, *Natica clytia*, *Astarte ovata*, *Gervillia aviculoides*, *Perna mytiloides*, *Corbicella lævis*, *Myoconcha Sæmanni*, *Lima læviuscula*, *Pecten lens*, *P. vimineus*, and spines of *Cidaris florigemma*.

In the evening Mr. Parker exhibited a collection of the fossils of the neighbourhood, principally from the Oxford Clay, Lower Calcareous Grit, Coral Rag, and Kimmeridge Clay. A number of interesting diagrams were also exhibited and explained.

On the following day the party left in carriages for Cumnor, 3½ m. S.W., Fyfield, 7½ m. S.W., and Marcham, 7 m. S.S.W. of Oxford. Near the Cumnor Clump is a pit in the Kimmeridge Clay, where the specimen of *Iguanodon*, recently exhibited at the Geological Society, was found. These remains, according to Mr. Hulke, illustrate nearly every part of the skeleton of an immature individual, which however differs materially from the Wealden fossil. Prof. Seeley even believed that the differences were important enough to place the animal in a new genus.

The following section of the *Iguanodon*-pit was drawn up by

* Blake and Hudleston, "Corallian Rocks of England," Quart. Journ. Geol. Soc., for May, 1877, p. 309.

Prof. Prestwich for the use of the party. Beneath a capping of Lower Greensand there comes—

a. Light-coloured and mottled Clay (altered).
b. Grey Clay with numerous small ferro-argillaceous concretions in the upper part—few fossils.
c. Layer of large flat Septaria.
d. Grey Clay, with seams of fossils, *Ammonites*, *Thracia*, &c., *Pliosaurus*.
e. Ditto with *Cardium*, *Trigonia*, &c., Vertebra of *Icthyosaurus*.
f. Thin ferruginous seam full of *Gryphœa vigula*, a few *Lingula*, &c.—*Iguanodon*-bed.

From the top of the hill near the Clump, there is a most extensive prospect, bounded at the far south by the Chalk escarpment. The day being very clear, Mr. Parker was able to explain his views as to the configuration of the district.

Shortly after regaining the high road, the party entered the very remarkable stone-pit on Bradley farm. There is much variety here within a short compass. The highest series is a mass of Coral Rag, here containing, for the most part, a large Monomyarian fauna, but with bands of the typical urchins. At its base is a white flaggy and shelly limestone, of very slight thickness, but important as occupying a position analogous to that of the great Shell-bed in the Headington district. Beneath this come loose sandy masses in places even argillaceous, and then a massive limestone grit, the lower portion containing a profusion of Gasteropoda. This may be regarded as a shell-bed towards the top of the Lower Calcareous Grit, and its contents are rather unusual. *Am. vertebralis* is common, *A. perarmatus* less so. There is an abundance of small *Naticæ* and one or two species of *Nerita* occur very similar to forms in the Bathonian beds, also a species of *Amberlya*, very similar to the *Amberlya nodosa* of the Great Oolite. It is, perhaps, the only place in England where *Chemnitzia abbreviata* has been found. To these we must add *Cylindrites Lhuidii* in great numbers, and several specimens of *Cerithium* and *Nerinæa* usually small. No lack of bivalves accompany these, but the assemblage of small and peculiar univalves is worthy of attention. The loose sands of the Lower Calcareous Grit underlie the bed.

The drive from Cumnor towards Fyfield presents no very marked geological features, but there are some interesting though rather obscure sections in the latter parish, where false bedding is seen on a very considerable scale.

The whole party were most hospitably entertained by Mr. Parker at Fyfield Manor House. A portion of the party afterwards paid a hasty visit to one of the celebrated Marcham quarries, where the Corallian beds are thin and variable, and where the uppermost Limestone (Coral Rag) is often replaced by sandy beds with concretions. Below this group comes the main Shell-bed of this district, here charged with a very large variety of *Trigonia perlata* and other fossils. The lower beds of limestone contain many specimens of *Natica*, but the peculiar fauna of Bradley is no longer found. The bottom of this quarry is very full of water. The great quarry whence so many Lower Calcareous Grit fossils have been obtained, was not visited, as the evening was drawing on, and the Members were anxious to return to Oxford.

EXCURSION TO AYLESBURY.

(*In conjunction with the Hertfordshire Natural History Society.*)

MAY 29, 1880.

Director:—W. H. HUDLESTON, ESQ., M.A., F.G.S.

(*Report by* THE DIRECTOR.)

On arriving at Aylesbury about noon, the first place visited was Mr. Hill's well-known brick-pit on the Bierton Road, where excavations have been going on for nearly a century, and where there is at present a very remarkable and instructive section, which has hardly attracted the notice that it deserves. The appearances in this section are singularly deceptive, and unless they were interpreted by the light of the recent drainage works are calculated to mislead the very elect themselves. The clay which is made into bricks is very sandy, and differs considerably from ordinary Kimmeridge Clay in the nature of its fossils, as does that at Mr. Locke's pit, near Hartwell, which is on the same geological horizon. In Mr. Hill's pit this clay is observed to change colour very much on approaching the surface, and the uppermost four feet are somewhat more sandy, thus facilitating a change, which is due to atmospheric agencies, and which may be observed in the exposed parts of nearly all clays, though the effects vary according to

original composition. Thus a highly fossiliferous clay, such as the top clays at Aylesbury and Hartwell, contains a large quantity of lime salts, which, rapidly yielding to the action of solvents, are often drawn out in the form of an efflorescence, the result being a random aggregation of calcareous matter, and the more or less complete destruction of the shells. That this is a reasonable interpretation of the phenomena in Mr. Hill's brickyard is rendered more probable by the fact that the recent drainage excavations have enabled us to observe the perfectly fresh clay, up to its actual junction with the overlying series, in which there is no discolouration, and where the fossils are specifically identical with, and as well preserved as those of the unweathered portions in the brick-yards.

The surface of the clay in Mr. Hill's pit is seen to be slightly undulated, which was generally interpreted by the members of the party as due to folding of the strata rather than to the effects of erosion previous to the deposition of the overlying series. Whatever the cause, the result is that towards the south-east part of the pit a slight trough contains a very good development of the basal conglomerate of the Portlands. This also has suffered from atmospheric influences, and few would recognise in its soft and variegated masses the "hard blue" of the drainers. Fortunately its lowest bed contains an abundance of small black pebbles, which have withstood the vicissitudes of many a geological revolution, and thus bid defiance to the insinuating action of carbonated waters, which have so loosened the matrix in which they are contained. Some quartz is there, but the black ones go under the general and convenient term of lydite. These may be derived, some from palæozoic cherts, others from indurated siliceous beds of mechanical origin, such as are found in the very old rocks. They are extremely hard, but usually contain more alumina than true flint does. Along with these is a very fine series of Portland fossils, here much decayed, but well preserved in the blue bed, disclosed by the drains about twelve feet below the surface in the lower part of the Market Place, opposite the "Green Man." This fossil bed contains the same sort of ammonites as does the underlying clay, but many of the other species are here seen for the first time in England, and continue unchanged to the highest beds of the Portland rocks of this district.

Subjoined is a partial list of the fossils of these basement beds

found in the Market Place. The Clavellate *Trigoniæ* were excessively plentiful, and frequently found with both valves. The varieties are so numerous that the identifications are given with some hesitation. The fossils are large, and in bad preservation.

Ammonites biplex, *Pleurotomaria ? rugata* (small cast), *Pleuromya tellina*, c., *Pl. Voltzii*, c., *Unicardium circulare*, c., *Cardium Pellati*, r., *C. dissimile*, c., *Trigonia gibbosa*, *Trigonia incurva*, two varieties, c., *T. Pellati*, *T. Carrei*, r., *Mytilus jurensis*, c., *Pecten solidus*, *Lima* sp. r., *Ostrea* distorted forms.

This sudden advent of a partially new fauna was no doubt the result of physical changes in the neighbourhood, and the change in the composition of the beds, and more especially the presence of pebbles is seen to point in the same direction, and we may suppose that some interval of time elapsed between the deposition of the clay and of the conglomerate.

This conglomerate series is about four or five feet in thickness, and may be observed to have in many places a yellowish green colour, due to the quantity of green earth or glauconite which it contains; though, like everything else near the surface, it is very much decomposed. But when the soft rock is cut with a knife a green tinge is very manifest. The underlying clay also contains abundance of this green earth, but it requires levigation to separate it along with the fine quartzose sand from the clayey particles which invest it.

The formations of the Secondary Period which occupy the Vale of Aylesbury from the uppermost Kimmeridge Clay to the beds which form the base of the Chalk, contain at intervals a large proportion of this green earth. Indeed, the various Greensands have received their name by reason of this peculiarity, though the name in some instances is unfortunate in its application—as are most lithological terms when applied to geological formations—since much of the so-called Greensand is, in its present condition, very destitute of this valuable fertilizer.

The richness of the Vale of Aylesbury has long been proverbial, and really high rents were paid here at a time when a large part of such a county as Norfolk, for instance, was in the condition of uncultivated heath. Many concurrent causes have contributed to this result. Firstly, from one of those accidents which are so difficult of explanation with regard to superficial accumulations, there is hardly any Drift in this region, so that the rich clays and

marls of the Secondary formations are not masked by a mass of Glacial rubbish from the north. The two staples of the Vale are the Kimmeridge Clay and the Gault. These are themselves very rich in phosphatic matter, doubtless arising from the immense quantities of vertebrates entombed therein. But clay alone won't do; we must have lime and sand. These are most happily supplied in the shape of numerous outliers of Portland limestone resting on sands, glauconitic beds, and frequently covered by sands again. The rainwash of many ages has, from time to time, carried down a portion of these substances and spread them over the clays, so that there has been a happy mixture of the right sort. The Chalk in the same way has helped to marl the Gault, though much of that formation is almost a marl itself of prodigious fertility. All that was required in time past has been to remove stagnant water from the land by means of draining, and the best results have been obtained. It can hardly be doubted, however, that dairy farming, and especially the practice of selling the whole milk so prevalent in this highly favoured district is very much like spurring a willing horse to the verge of exhaustion. An enormous quantity of phosphate, to say nothing of other substances, is removed in milk. The farmers best know what equivalent they supply. Thus the phosphates at the surface stand a chance of being run out, and although there is probably an inexhaustible store some feet below the surface, it may be questioned how far this is economically available.

The party on leaving Mr. Hill's brickyard passed through the town of Aylesbury, some calling for a few minutes at the "George." As it was market day the streets were rather crowded, and there seemed at one time some danger of straggling. Mr. Robinson, the clerk to the drainage works, was able to point out a section, not yet filled in, on the brow of the hill looking towards Hartwell. The valley of the Thame at Aylesbury is about 250 feet above sea level, and the summit crowned by the church is, say, 300 feet, making the height of the hill on which Aylesbury stands about 50 feet above the low grounds. More than half of this is occupied by the peculiar type of Kimmeridge Clay previously described. Above comes the blue bed with its lydites, &c., also previously described, and above this a few feet of loose yellowish sand. On this sand rests seven or eight feet of white limestone or roche, with thin seams of sand in places. It is not known what occupies the very top of the hill, as the drains were not taken through the summit.

About three feet of made soil covers all the above beds in succession. The roche represents a certain variety of the Portland limestone, but it would seem as though the very highest beds of that rock were not reached in the drains. The character of the stone and of the fossils would seem to show that part, at least, of the roche at Aylesbury corresponds to the Middle-limestones, which are well developed in neighbouring localities, and which are recognized by a certain assemblage of fossils. Shells, mostly of great size, were thrown out by scores, in various states of preservation, just beneath the George Hotel, when the drain was being carried through the Market Place. Certain beds seemed to be charged with particular groups of fossils, but as these were for the most part mingled together on the heaps no very accurate observations could be made. Subjoined is an imperfect list:—

Ammonites biplex, *A. boloniensis*, *Natica elegans*, *Natica*? species, *Pleurotomaria* and *Trochus*, both small; *Pleuromya tellina*, c., *Quenstedtia*, sp., *Cyprina* (two small species), c., *Myoconcha Portlandica*, c., *Lucina Portlandica* or *plebeia*, r., *Cardium Pellati*, r., *Cardium dissimile*, c., *Trigonia gibbosa*, several forms of Clavellate *Trigoniæ* (same with both valves), c., *Arca* cf *Menandellensis*, c., *Modiola boloniensis*, *Mytilus jurensis*, *Perna Bouchardi*, c., *Pecten lamellosus*, c., *P. solidus*, *Lima rustica*, c., *Lima boloniensis*, r., *Exogyra bruntrutana*.

At the bottom of the hill on the Oxford Road, but rather below its level, there occurs a clay of a very different character to the typical Hartwell clay of Mr. Hill's pit at Aylesbury and of Mr. Locke's pit at Hartwell. This also was exposed in the drains. A short search for fossils in this clay did not disclose anything very remarkable, though an ammonite different to the form so characteristic of the uppermost clay was noted. Still the typical fossils of the Kimmeridge Clay were not found. A very sandy stratum is said to occur below this again, but the authority for the statement may be doubtful.

The party of geologists re-assembled in Mr. Locke's brickyard, which, in its geological position, is analogous to the one described at Aylesbury. The Hartwell clay is here seen at the south-west end to be overlain by a somewhat altered representative of the glauconitic or lydite series, which forms the base of the Portland-rocks in this part of the country. It is fully five feet thick, and the bottom bed, which contains the bulk of the lydite, is not easily

uncovered. The beds are also much more calcareous than the equivalent series at Aylesbury, and less decomposed. On the whole, too, they are more varied, and the glauconitic character is much less marked. Very few fossils were obtained from the Hartwell clay on this occasion, the time of year not being favourable. The Director, however, briefly commented on the nature of the fauna, as shown in the collections which have been made from here, pointing out that three most characteristic fossils of the Kimmeridge Clay, viz., *Rhynchonella inconstans*, *Ostrea deltoidea*, and *Exogyra virgula*, have never yet been found. The fossils prove it to occupy a higher horizon than the Kimmeridge Clay at Oxford for instance. It is in fact on the horizon of the Middle Portlandian of Boulogne, as was maintained by M. Edmund Pellat, when the Geologists' Association visited the Boulonnais two years ago, under the direction of that distinguished jurassic geologist.

The following partial list may serve to show the character of the fauna :—*Belemnites Souichii*, *Ammonites biplex* two forms. Gasteropoda are rare in the upper clays ; a *Cerithium* near to *septemplicatum* is the most common, and a *Pleurotomaria* very like *rugata* occurs. *Pleuromya tellina*, c., *Pholadomya* cf *tumida*, r., *Thracia tenera*, c., *Corbula* cf *Bayani*, c., *Cyprina implicata*, c., *Astarte Hartwellensis*, c., *Astarte Sæmanni*, *Ast. scalaria*, c., *Lucina lineata*, r., *Cardium morinicum*, c., *Trigonia Pellati*, *Trigonia* near to *incurva*, *Arca texta*, c., *Mytilus autissiodorensis*, c., *M. boloniensis*, c., *Pinna suprajurensis (Constantini)*, *Perna Bouchardi*, c., *Avicula octavia*, *Pecten Morini*, c., *Ostrea* near to *expansa*, c., *Ostrea bononiæ*, c., *Exogyra bruntrutana*, *Exogya carinata*, *Waldheimia boloniensis*, r., *Rhynchonella subvariabilis*, r. The variety of Oysters is very remarkable, and some forms of this genus are, perhaps, almost unknown elsewhere. Anyone desirous of making new species might have a fine opportunity here.

Thence the party proceeded to the "Bugle" pit, where the junction of the Portland limestone with the Purbecks may be seen. Following the sequence from Locke's clay pit it is possible to calculate with tolerable accuracy the thickness of the Portland rocks at Hartwell. We calculate from below upwards. Above the Hartwell clay the impure limestones and glauconitic sand associated with the lydite bed have a thickness of five feet. In the "Bugle" pit, what seems to be the top of this series is known as the blue bed, and above it lie four and a half feet of loose yellowish sand.

An excavation in the shape of a grave had been dug in this sand to enable the Members to see the top of the blue bed, but the workmen declined to go further, as when the blue bed or double rock is pierced the water which lies on the top of the clay is said to force its way through. Next above the loose sand come two feet of hard building stone with few or no fossils, and above this again comes the main body of the Portland limestone. This, including partings of a variable nature, measures nine feet, so that the entire Portland series to the base of the Pendle of the Purbecks is probably under twenty feet. The fossils which come from these upper Portland limestones are well known, and many specimens of *Ammonites boloniensis* have been built into the wall of Mr. Lee's park. The most curious thing is, that with the exception of certain species common to all the Portland Beds, the fossils here are very different to those in the stone found in the Aylesbury drains. These limestones in fact belong to the Upper series, whilst those at Aylesbury belong to the Middle series. This is intelligible enough, but where is the Middle series at Hartwell?* We have the bottom series (basement or blue beds) and the top series, but the middle series is wanting, or has assumed another form. Such a fact serves to show how variable in their development these Portland rocks must be. The Purbeck beds of this quarry have not yielded many fossils, but some others in the neighbourhood have furnished insect remains and certain varieties of fishes. The beds are estuarine in character.

The remainder of the formations occupying the surface on the high grounds towards Stone are of a very sandy nature. It will be observed that there is a considerable degree of inclination in the pits and quarries hereabouts, whereby a certain degree of irregularity is imparted to the relative position of the beds, so that without the aid of fossils their precise geological position is uncertain beyond the general fact that they are of Neocomian age. The white sand pits show many feet of nearly pure white sand with here and there layers of carbonaceous particles. The probability is that these sands have been bleached by action of organic acids arising from the decomposition of woody or at least vegetable matter which has run out the iron and other soluble substances, leaving a nearly pure silica. The very best quality has been much used for

* Until the rock has been pierced right down to the Hartwell clay there is really no satisfactory evidence as to the thickness of the Portland Rocks. —W. H. H.

glass making, but is at present undersold by sands enjoying superior facilities of carriage. In the principal sand pit on the north side of the main road there are a number of siliceous concretions of a peculiar strangulated appearance, long known to the country people as "the Doctor's bowels"—some of these are built into the park wall along with the ammonites. A member of the party observed that the texture of this stone is different to that usually known as Sarsen-stone, being much coarser.

The company now separated, the larger portion returning straight to the town, whilst some accompanied the Director to the summit of the Round Hill, whence there is a magnificent prospect of the Vale of Aylesbury looking south in the direction of the Chilterns, and also looking north over the valley of the Thame. The topography of the region as subordinate to its geological structure was indicated. The innermost line of Portland Rocks (sometimes covered by Purbecks and Neocomians) parallel with the Chilterns, has a length of ten miles from Thame to a little beyond Aylesbury. Upon a portion of this continuous mass the party were now standing. It has the river Thame as a sort of wet ditch on its northern flanks. This flows over Kimmeridge Clay. The first system of out-works beyond the line of the Thame is to be seen in the ridges of the Winchendons, of which Coney Hill is the eastern extremity, though the little outlier of Weedon belongs to the group. The second and still more isolated system of outworks is to be sought in Ashendon, Lodge Hill, and the very large outlier which supports the villages of Pitchcote, Oving and Whitchurch. The most detached summit of all is Quainton Hill, forming part of a third series of outworks. The Portland rocks are probably thicker at Quainton (they certainly are at Lodge Hill) than at Hartwell, indicating a tendency to thin out to a feather edge on the south. They also show a mean fall of between three and four hundred feet in the seven miles, giving a dip of about half a degree to the S.S.E. All this cutting away of the intermediate rock is the result of aqueous agencies, determined most probably in the first instance by folds in the beds. Reverting now to that far more distant period when the Portland rocks, instead of being carved out into separate hills, were being laid down as sediment not yet consolidated in the waters of a shallowing sea, the Director speculated on the possible shore lines of such a period in this area. The remarkable analogy which in some respects the Portland Beds of Bucks present to those of the

Boulonnais, which all geologists agree were deposited not far from a promontory of the old Ardennes ridge, might lead to the supposition that the influences of such a ridge, even if not actually above water, have made themselves felt in the migrations of mollusca, and also in the nature of the deposits, though those of the Boulonnais are even more sandy than in Bucks, where there is at least one tolerably pure limestone. From recent borings the undulating character of the old Palæozoic floor, upon which the Secondary beds must rest, may be inferred, but it is equally clear that the Mesozoic column becomes thinner as we advance northwards from London, as shown by the boring at Ware which reached Silurian rocks at a depth of 800 feet. It is also equally certain that the Jurassic rocks are absent altogether beneath Ware and London. We cannot therefore expect that these various beds seen to-day, including the clays on which they rest, have any great extension within the Chalk area, beneath which we see them dipping. Somewhere between here and London they are sure to knock up against the old rocks, and when we remember the oscillations that have taken place at various epochs, it is not difficult to believe that, during the Portland period, either a shore line or a line of rocky shallows was not far off in a southeasterly direction. At present the thickness of the Secondary rocks here may be about 1,000 feet; they are 800 feet thick at Ware, 30 miles to the east, and 1,200 feet thick at Burford, 36 miles to the west. The boring at the Asylum, near Stone, close by, went through 570 feet of beds, and terminated somewhere in the Oolitic formation.

For a long period, in the interval which preceded the deposition of the Chalk, this region underwent considerable vicissitudes, accompanied by much denudation. Then came a time when the whole region, far and wide, sank, and the Cretaceous sea flowed over everything for ages. The story of the uprise of its deposits and of their sculpture, whereby the great escarpment of the Chilterns was produced, belonged to another chapter in the chequered history of the earth.

In the Bugle pit they had been joined by the Rev. C. Lowndes, vicar of Hartwell, who was kind enough to supply the Members with much interesting information relative to that parish.

Before breaking up the Members tendered a hearty vote of thanks to Mr. Hudleston for his kindness in describing the phenomena inspected.

On the Origin and Petrology (Specially of the South Side) of Salisbury Crags, Edinburgh.

By Andrew Taylor, F.C.S., Assistant Secretary of the Botanical Society of Edinburgh.

Read December 5th, 1879.

(*Abstract.*)

The author was inclined to trace the origin of the Crags to some movement connected with the warping of the adjacent Midlothian coal basin—possibly, too, the upheaval of the Pentlands. Lateral compression, or forces acting simultaneously in two directions, may have caused Crag-structure. The greenstone, or dolerite, may not have been ejected as a fluid lava, but as a loose ash-bed, and its compact structure may be due to subsequent consolidation.

Many of the features connected with the great earthquake wave of 1868, in the Sandwich Islands, as described by Mr. Brigham in the Memoirs of the Boston Society of Natural History, afford comparison for study of the natural history of Salisbury Crags. A great band of mud issued out of no crater—but an earth chasm—and spread for miles in a few hours. It speedily showed chasms and cracks, while alkaline vapours were perceptible at certain parts of its course. In a short time after its formation, a native thrust in his hand into the mass, to find it perfectly cold. It is conceivable that the Crags could thus have issued from one or two earth chasms. And particular attention was called to several spots down from the great quarry on the south side, as well as on to the convergent slope to the Hunter's Bog, in proof of this. Hutton, no doubt, gave his dictum that the aqueous strata of the Crag were similar to those now forming by modern causes. But, in order to draw a parallel betwixt the greenstone and modern lava, his adherents had to postulate its formation under great pressure, probably under ocean depths. Prof. Jamieson has elaborately shown (Edin. Phil. Journ., Vol. i, 1819) that the strength of the Neptunian argument lay in the difficulty of proving the so-called aqueous strata to be identical with those now forming by modern causes. Boue quietly hinted that the sandstones, shales, and limestones of the hill were a special formation. Indeed, the large quartz crystals in the sandstone of the quarry of the Hunter's Bog, as well as the marked petrological appearances of the

sandstones of the neighbouring Grange district suggest this. On the other hand, the marked physical appearances at the junctions of the igneous and aqueous rocks have been the strongest points of the Huttonians. Recent microscopic examinations show no distinctive differences betwixt the two rocks; nor have they proved the dolerite identical with Vesuvian lava. According to Professor Hull, no British dolerite, except that from the Wolf Rock, is so.

Mr. Ivison Macadam, F.C.S., made the accompanying analyses, which tell their own story in this description. They relate first to an upright vent or thin mass of white rock to be found just below the southern termination of the great quarry. The ground immediately above the footpath is covered by great *débris* heaps, but the observer surmounting these will find the spot without difficulty; indeed the white streak in the rock marking the site of the vent is so prominent as to be seen from the neighbouring houses.

The analysis shows the red sandstone of many authors to be a dolomitic limestone. The pocket at the northern extremity of the great quarry, classical in all local descriptions because supposed to give ocular proof of the decolorising power of the surrounding liquid lava, may then be due in some sort to crystallisation. Near this the dolerite beds may gradually be seen passing from the coarse-grained into the hard sonorous variety; calcite and zeolites are seen by the naked eye to be predominant features of the rock. Indeed we are reminded of Daubrée's synthesis of such rocks from Roman bricks at Plombières. So, too, does the white vent. It is about five feet broad, and veins of calcite break and ramify, in a vertical line, through part of it, leaving slickenside markings on the walls. Daubrée has shown that calcite may be deposited at a temperature of 70°C. If Sir James Hull's hypothesis that it was formed under great pressure were correct, it should prevail as much in the dolomite as in the greenstone. The great quantity of iron prevalent is notable. Professor Geikie has shown that this peculiarity is seen also by the microscope. The greenstone has thus a composition and specific gravity different from Vesuvian lavas. According to Huttonian ideas the red colour of the dolomite was due to iron filtered into it by the heated superincumbent lava; but Jamieson's "slate clay" underneath it has much more iron, nearly as much as the greenstone itself. The presence of a small quantity of copper is notable; it has previously been observed in similar rocks on the Braids and at Currie. Jamieson has noted in the sandstones of the city, galena, iron pyrites, and blened;

small quantities of cobalt-ore were also found in a whin dyke in Albany Street. In walking along the footpath behind the Crags, immediately after crossing through the Hause, small patches of this dolomite may be observed in the greenstone; beautiful blebs of calcite here come up through it. Little veins of iron ore and greenstone may also be seen traversing the footpath, still further up taking a zigzag form, now longitudinal, now vertical, and finally terminating in the abrupt front of the Crags. So, too, do parts of the parent rock show the main vein and cross vein structure in hand specimens. This suggests a method of Crag building for this southern end, which is all greenstone, and which is twice as steep on this face as the further portion where the sandstone comes on. Maclaren has pointed out the great hummock of trap running up in the direction of the Cat's Nick. Similar hummocks, though much smaller in size, may also be noted to run up to the vents indicated in this paper. Immediately above the first great quarry portions of the rock were bared, under direction of Sir Henry James, for geological study. Attention is called to two phenomena—leaving glacialists to expatiate on ice scratches said to be disclosed. Fleming describes what he called flaws—"This surface is marked by numerous small parallel ridges, seldom reaching two inches in breadth, very shallow, scarcely exceeding half an inch in depth, occasionally preserving for a couple of yards their distinctive character, at other times slightly waved, but throughout exhibiting generally a continuous parallel linear arrangement." They are observable on the sandstone of the Bog Crag and on the red-stone of the footpath of the Radical Road, below where we are now supposed to stand; they are not ripple marks: And the analyses adduced may remove the objection to their being considered marks of the contraction of the rocks. On a space of open rock near to this a series of elliptical holes about an inch long and as much apart is disclosed for a space of seven feet or so. These may be called steampores.

Maclaren makes this south side of the Crags to have been formed with the rest of Arthur's Seat long after the other part of them. The author eschews chronology in this paper. Neither does he trace the southern termination of the greenstone bed beyond the Hause into Arthur's Seat. Perhaps the bed of siliceous limestone found just beyond Samson's Ribs may be the continuation of that which is lost in the cutting into which the Queen's Drive plunges.

Former controversialists on the age of Arthur's Seat have begun at the top, Hebrew-wise, reading the stone-book backwards. The author's only contribution to the controversy would be to begin with the foundations of their argument, briefly saying in Scotch law fashion, *quoad ultra*, denied! The author considers the petrological peculiarities of St. Leonards and Salisbury Crags are such as to take them out of the regular bedded sequence usually given them in diagrams illustrative of the age of Arthur's Seat. Dr. Hibbert, in writing of the extinct volcanoes of the Giffel, shows that, in the deposit of the basin of the Rieden, floods of water, carrying mud and ashes, were contemporary with the flow of trachytic and basalt dykes. He suggests that, during the eruptions, the superambient waters of the lake, heated and saturated with gases from the crater, would be imbued with a new power of effecting chemical change. The petrology of the Crags suggests similar analogies. If the great zone of boulders of the Hunter's Bog, and elsewhere, had been separated from the parent rock at the intersections of the bedding, during the ash and basalt flows going to form the Crags, heat sufficient to effect great change must have arisen. Daubrée has shown how dry clay triturated against itself, had its temperature raised in three-quarters of an hour from 18° C. to 40° C., and thus speculates how mechanical force may be transformed into heat, as on the Alps. The slickensides and flaws so abundant round Arthur's Seat acquire new significance in the light of this experiment.

The first of the samples analysed was taken from the vent itself; the second from the rock next to and surrounding the vent; whilst the third analysis shows the composition of the main or unaltered rock.

No. 1 *Sample* is soft and friable, and is readily pulverized to a light green powder. Specific gravity 2·619. It is evidently an altered greenstone. The powder yields effervescence on treating with an acid.

No. 2 *Sample*, or the rock surrounding the vent, is of a much darker colour than the rock of the vent. It is compact and hard, and shows veins and cavities filled with calcite crystals. It gives a grey powder when pulverized. Specific gravity of rock 2·707. The powder shows effervescence on the addition of acid.

No. 3 *Sample.*—The rock mass has a specific gravity of 2·806. The powder effervesces slightly when treated with acid.

No. 4 *Sample* is from a bed of limestone lying under the green-

stone. It is of a reddish iron colour, and is somewhat crystalline. When acted upon by acids it effervesces much, and yields a solution with a slight yellow tinge. The specific gravity is 2·637.

No. 5 *Sample* was obtained from a bed of sandstone underlying the limestone. It is greenish-white in colour, and is close-grained. When treated with acids it shows effervescence. Specific gravity 2·421.

No. 6 *Sample* is from the same stratum as No. 5, only it was taken further from the limestone and nearer the bottom of the bed. It has a slight green tinge of colour, and shows rust marks at parts. When acted on by acids it gives very slight effervescence. Specific gravity 2·536.

The average results of several analyses of these three minerals yielded the following figures calculated to percentages.

A. *Soluble in Acids.*	*No.* 1. *Rock forming Plug of South Vent.*		*No.* 2. *Rock lying next to South Vent and altered.*		*No.* 3. *Rock mass pierced by South Vent, but unaltered.*	
Ferric Oxide (Fe_2O_3)	12·68		13·96		20·94	
Aluminic Oxide (Al_2O_3)	2·18		3·36		6·38	
Calcic Oxide (CaO)	11·37		18·65		1·86	
Magnesic Oxide (MgO)	0·74		0·75		0·73	
Cupric Oxide (CuO)	0·42		0·43		0·33	
Carbonic Anhydride (CO_2)	9·34		15·08		2·86	
Soluble Silica	0·06		0·07		0·06	
Potassic Oxide (K_2O), Sodic Oxide (Na_2O), Loss	2·18		1·35		0·21	
Total Solution in Acids	——	38·97	——	53·65	——	33·37
B. *After fusion of the insoluble portion, and treatment for the second time with acids.*						
Ferric Oxide (Fe_2O_3)	10·05		4·13		8·54	
Aluminic Oxide (Al_2O_3)	8·42		5·32		4·66	
Calcic Oxide (CaO)	3·85		0·43		3·44	
Magnesic Oxide (MgO)	0·33		0·03		2·86	
Potassic and Sodic Oxides and loss	0·32		0·01		0·69	
Soluble after fusion	——	22·97	——	9·92	——	20·19
Insoluble Silica		35·74		34·97		45·38
Moisture		2·32		1·46		1·06
		100·00		100·00		100·00

A. *Soluble in Acids.*	*No. 4.* *Limestone below greenstone and cut through by South Vent.*	*No. 5.* *Sandstone below and next to the limestone.*	*No. 6.* *Sandstone below limestone and lower down in stratum than No. 5.*
Ferric Oxide (Fe_2O_3)	2·28	0·77	0·68
Aluminic Oxide (Al_2O_3)	0·38	1·46	1·53
Calcic Oxide (CcO)...............	18·95	9·18	1·14
Magnesic Oxide (MgO).........	11·77	0·19	0·16
Carbonic Anhydride (CO_2) ...	35·79	5·78	1·20
Soluble Silica......................	0·03	0·05	0·04
Potassic and Sodic Oxides and loss	0·51	0·34	0·41
	——69·71	——17·77	——5·16
B. *After fusion of the insoluble portion and treatment for the second time with acids.*			
Ferric Oxide (Fe_2O_3)	——	10·98	2·44
Aluminic Oxide (Al_2O_3)......	——	0·03	0·12
Calcic Oxide (CaO)	——	0·22	1·13
Magnesic Oxide (MgO)	——	trace	0·84
Potassic and Sodic Oxides and loss	——	trace	0·59
Soluble after fusion......	——	—— 11·23	—— 5·12
Insoluble Silica............	28·93	69·83	88·68
Moisture.....................	1·36	1·17	1·04
	100·00	100·00	100·00

ORDINARY MEETING.

JUNE 4th, 1880.

J. LOGAN LOBLEY, ESQ., F.G.S., in the Chair.

The Donations to the Library received since the previous meeting were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association:—

Francis Bond, Esq., F.G.S.; Leonard P. Boyce, Esq.; George Forman, Esq.; Duncan M. Kirby, Esq.; Daniel Lambert, Esq.; Raphaël Meldola, Esq.

The following Paper was read:—

ON THE FISH FAUNA OF THE YORKSHIRE COAL FIELD.

BY JAMES W. DAVIS, F.G.S., &c.

CONTENTS.—Extent, boundaries, and character of Coal field—Distribution of fossil fishes—Their very slight variation in successive strata through a large vertical series—Lower Coal Measure fishes and those of Middle Coal Measures—Characters of fossil fishes and their relationship to existing forms—Elasmobranchs or Sharks—Ganoids—Tabular enumeration of genera and species, with localities—Marine and fresh-water fishes mingled indiscriminately—General character of some of the commoner forms—Comparison of the fish fauna of the Yorkshire Coal field with those of Lancashire, Staffordshire, Newcastle, and Scotland.

The Coal Measures of the West Riding of Yorkshire, until recently, have received little attention so far as their palæontology is concerned. Their stratigraphical features have been worked out and developed most carefully, not only by private enterprise for commercial and industrial purposes, but also in a more thorough and scientific manner by the officers of the Geological Survey. The Memoir on the Yorkshire Coal Field, recently completed by Prof. Green, now of the Yorkshire College, and his associates, will, perhaps, take rank as the most elaborate and important work issued by the Survey. The value of this intricate and detailed accumulation of facts cannot be over-estimated, and to the practical miner or the more philosophical geologist or palæontologist the book must be one of constant use and refer-

ence. Already the workings in this Coal Field have been extended considerably under the Permian Limestone, which, in the earlier days of geological science, was thought to be its eastern limit, and pits sunk to the depth of over 1,500 feet have proved that the Silkstone Coal exists over a large area where only the Barnsley Coal has previously been got; indeed, the only eastern limit to the Yorkshire Coal Field will be caused by the great depth at which the coal lies buried. To the north and west the Coal Field is encircled by the older beds of the Millstone Grit series. The latter, forced up during a post-Carboniferous epoch, form the elevated Penine chain of hills which now separates the once united Yorkshire and Lancashire Coal Fields. The Millstone Grit rocks merge gradually, and without any distinct or arbitrary dividing line, into the Coal Measures. The thick-bedded, often coarse, grit rocks, with thick intermediate beds of shales, give place to finer sandstones and shales, with occasional coal seams in the Lower Coal Measures, and these again to the more rapidly alternating shales and sandstones and frequently recurring coals of the Middle Coal Measures.

The fossil fishes in the Coal Measures of Yorkshire hitherto discovered have been principally found in two or three localities. In almost every instance where those remains have been found they are obtained from the shale immediately above a coal bed, and they usually present the same features throughout the whole series. The genera of fish found in the Lower Coal Measures are also found in those higher in the series, but there is not always the same proportion of individuals of any given genus in the same beds. Some genera are of frequent occurrence in the higher beds, whilst in the lower, though still present, they are in much diminished numbers. The fishes are not often found over large areas; even when a seam of coal above which they have been found to occur in tolerable abundance in one locality extends persistently over a large area, it does not follow that the fossil fish will be uniformly distributed over that area; in most instances, on the contrary, the fishes are discovered in certain districts, whilst in others the same bed, on the same horizon, is unproductive. It is worthy of remark that where fish are found above any given bed of coal, though the situations may be widely separated, there is a close relationship between the fish of the several localities; for example, the Halifax Hard-bed Coal in the neighbourhood of the town from which it derives its name has yielded remains of *Mega-*

lichthys, *Cœlacanthus*, *Acanthodes*, and others. At Baildon, near Leeds, where fish remains have also been found above this coal, they are generically identical. The specimen which served as the type for Prof. Agassiz's description of the genus *Cœlacanthus* was obtained from a large nodular mass locally known as a "baum-pot," above the Hard-bed Coal at Halifax. Fish remains in the Halifax Beds are not common, and when found are nearly always associated with Mollusca of a marine origin, such as *Goniatites*, *Nautilus*, *Avicula-pecten*, and *Orthoceras*. About 700 feet above the base of the Coal Measures is the Elland Flagstone, known south of Huddersfield as the Grenoside Rock, and immediately above these flagstones there is a bed of coal two-and-a-half feet thick—the Better-bed Coal. It is peculiarly free from sulphur, and in consequence is valuable for iron smelting. The excellence of the Low Moor iron has been attributed in a great measure to the use of this coal. It possesses a further characteristic of interest to students of fossil botany—viz., that in some parts of the seam the coal is made up of the macrospores of fossil plants, so well preserved that the microscope reveals their structures and affinities with much perfection. The most important feature in connection with this coal, for our purposes, lays in the presence of a thin stratum of shale immediately above the coal, which is to a very great extent made up of fish remains. So completely is this the case that I have ventured in the "Quarterly Journal of the Geological Society" to describe it as Bone-bed.* It extends for several square miles, overlying the coal, and is nowhere more than half an inch in thickness. From this thin stratum have been obtained nearly forty species of fossil-fish and labyrinthodonts. The remains are frequently broken, and appear to have been a good deal rolled about before they became finally embedded. They consist of about equal proportions of marine fishes and of those whose representatives live in fresh water at the present time.

The next important coal is the Black-bed seam. It is extensively wrought near Bradford and Halifax. In the shale above the coal is an extensive deposit of clay-ironstone, the two being worked together. Many important fossils have been found in the shale near its junction with the coal, and especially a large labyrinthodont—*Pholiderpeton scutigerum*—named and described by Prof. Huxley. From the Black-bed Coal to the Silkstone or

* Quart. Journ. Geol. Soc., Vol. xxxii, p. 332. Aug., 1876.

Blocking Coal—which is regarded as the dividing line between the Lower and Middle Coal Measures by the officers of the Geological Survey—there are several important coal seams, but I have not succeeded in finding any fish remains in connection with either of them.

The Middle Coal Measures include all the remaining strata of the Yorkshire Coal Field. Three or four beds of coal in these measures have yielded fish remains, the Silkstone Coals, the Middleton Beds, near Leeds—from which the Agassizian genus *Megalichthys* was derived, the specimen being now in the Leeds Museum—the Joan Coal, and the Cannel or Stone Coal, worked at Bruntcliffe, Ardsley, Tingley, and one or two other places. The latter contains a more remarkable series of fossil fish than any other stratum in this district. A detailed description of this coal may be found in the "Proceedings of the Yorkshire Geological and Polytechnic Society" for 1878. It occupies a basin-shaped hollow, extending only a few miles, and thinning out in every direction from the centre. Other similar areas,* on the same horizon, are filled with beds of Cannel Coal, extending southwards from Tingley, but in no other instance, so far as I know, do the coals possess so rich a fauna as the one named. The Cannel Coal is divided into two parts by an intervening bed of black carbonaceous shale. At its base is a bed of ordinary coal, and above it a shale filled with ironstone nodules. Both the shale and ironstone contain immense numbers of shells of *Unio* or *Anthracosia*, as well as a large series of plants. The fossil fish preserved in this coal are found in greatest abundance at the junction of the Cannel Coal with the intermediate shale, but they are also scattered somewhat indiscriminately throughout the coal.

Having thus briefly summarised the various strata in the West Riding from which fish remains have been obtained, I purpose to consider the several characteristics of the fossils and their relations to existing species, so far as they can be made out. The fish of the Coal Measures have been hitherto regarded as belonging to either the Elasmobranchs or Ganoids. In recent sharks the whole of the framework of the body is frequently cartilaginous; the vertebra, the brain-case, and jaws are all composed of cartilage; the teeth and dermal tubercles or shagreen, and when present, the spines protecting the dorsal or pectoral fins are the only parts of the fish which are composed of bone, and, as would naturally

* See "Geology of the Yorkshire Coal Field," by Prof. Green, &c., "Survey Memoir," 1879.

be inferred, they are the only parts of these fish which are found fossil ; all the remaining cartilaginous and soft parts have been decomposed and lost. Nor is this the only difficulty ; the cartilaginous framework which held the teeth and spines together being removed, the latter became separated, and now there are few instances where the teeth and other fossil parts of the fish can be correlated. It is an extremely rare occurrence to find the spines, teeth, or dermal shagreen in such relationship with each other that it can be clearly demonstrated that they belong to the same species, or even the same genus of fish. The organs on which modern classification is based—viz., the dilated aorta or *bulbus arteriosus*, with its variable series of valvular openings, the non-decussating optic nerves, the spiral valve in the intestine—all serve to distinguish the sharks and the Ganoids from other fishes at present existing. In the fossil fish of the Coal Measures the heart, brain, and intestine have now no existence, and we can only reason by analogy that as in recent fish we find certain functional relations existing between the soft and hard parts of the fishes, so in the fossil, having found the hard bony parts preserved, and these exhibiting certain close relationships with the recent forms, it is inferred that the soft and decayed portion of the fish have also borne a similar relationship to the recent forms.

The Ganoids are more numerous in the Coal Measures than the Sharks. Their remains are found in better preservation, their bodies being covered with a dense bony envelope of shining scales of ganoine, and the internal framework being, in most instances, more or less ossified, the fossils are generally discovered in a tolerably perfect condition. In recent forms the Ganoids exhibit in some particulars close relationship with the Elasmobranchs; the *bulbus arteriosus*, with its many valves, more numerous in the Ganoids; the chiasmic, non-decussating optic nerves, and the spiral valve in the intestine are all present, whilst in no other fishes are these characters to be found. There are other characters in which the Ganoids differ from the Sharks. In the latter the branchial arches are attached to the outer wall of the gill-cavity; the water enters by a number of slits in the dermal covering, usually five in number, and there is no operculum. The Ganoids have free gills and an operculum, and in this respect they have near affinities with the Tileostei, whose gills are not attached to the walls of the gill-cavity, and they are protected by an operculum which forms its outer wall. There are other important characters

in which the Ganoids resemble the Teleostei, notably in the possession by some of them of an air-bladder, which is preserved in the fossil state in the Ganoids; and also in the fact that many of the Teleosteans are possessed of a dermal covering of ganoine, developed from a membranous skin. I do not intend to enter fully into the several reasons for supposing that some of the Carboniferous fishes exhibit character or affinities which render their near relationship with the Siluroid Teleosteans probable, but further discoveries of fossil forms, more especially in beds which are of decidedly fresh-water origin, will most likely reveal closer alliances between the fossils and the recent Teleosteans than has hitherto been considered probable.

	Halifax Hard Bed.	Better Bed Coal, Clifton.	Blackbed Coal, Low Moor.	Silkstone, or Blocking	Middleton Main Coal.	Yard, or Iron Coal.	Adwalton Stone, or Cannel Coal.	Barnsley Thick Coal.
Ctenodus.								
ellipticus, H. & A. ...	.	*	.	.	.	.	.	.
tuberculatus, H. & A.	.	*	.	.	.	.	.	.
elegans, H. & A.	.	.	.	.	.	.	*	.
Cælacanthus.								
lepturus, Agass. ...	*	*	*	.	*	.	*	.
elegans, Newb. ...	.	.	.	.	.	.	?	.
Megalichthys.								
Hibberti, Agass.	*	*	*	*	*	*	*	.
coccolepis	.	.	.	.	*	.	.	.
Strepsodus (Holoptychius)								
sauroides, Huxley ...	.	*	*	.	*	*	*	.
Acrolepis, sp. (?)....................	.	*	.	.	.	.	*	.
Platysomus, sp. (?)..................	.	*	.	.	.	.	*	.
Rhizodopsis, sp. (?)..................	.	*	.	.	.	.	*	.
Acanthodopsis.								
Egertoni, H. & A.	.	*	.	.	.	.	.	.
Amphicentrum.								
sp. (?)	.	*	.	.	.	.	.	.
Palæoniscus.								
sp. (?)	.	?	.	.	.	.	?	.
Cycloptychius								
sp. (?)...............	.	*	*	.	.	.	*	.
Gyrolepis.								
Rankini, Ag.	.	*		.	.	.	.	.
Rhizodus.								
Hibberti, Ag.	.	.	*	.	.	.	?	.
Gyracanthus, Ag.								
formosus, Ag.......	.	*	*	.	*	.	*	.
tuberculatus, Ag	.	*	.	.	.	.	.	.
denticulatus, Davis	.	.	.	.	.	.	*	.

	Halifax Hard Bed.	Better Bed Coal, Clifton.	Blackbed Coal, Low Moor.	Silkstone, or Blocking.	Middleton Main Coal.	Yard, or Iron Coal.	Adwalton Stone, or Cannel Coal.	Barnsley Thick Coal.
Ctenacanthus, Ag.								
hybodoides, Egerton	.	*	*	.	*	*	*	.
æquistriatus, Davis	.	*	.	.	.	.	.	.
minor, Davis	.	.	*	.	.	.	.	.
Lepracanthus.								
Colei, Egerton ...	.	*	.	.	.	.	.	.
Hoplonchus, Davis.								
elegans, Davis	.	*	.	.	.	.	.	.
Acanthodes.								
Wardi, Egerton......	*	*	*	.	*	.	*	.
Phricacanthus, Davis.								
biserialis, Davis	.	*	.	.	.	.	.	.
Pleuracanthus, Ag., Davis.								
(Orthocanthus, Ag.)								
(Xenacanthus, Beyr.)								
lævissimus, Ag.	.	*	*	.	*	*	*	.
cylindricus, Ag.	.	*	.	.	*	.	.	.
erectus, Davis	.	.	.	.	.	.	*	.
tenuis, Davis	.	*	.	.	.	.	.	.
pulchellus, Davis......	.	.	.	.	.	.	*	.
alternidentatus, Davis	.	.	.	.	.	.	*	.
planus, Agass. ined...	.	.	.	.	?	.	?	.
alatus, Davis	.	.	.	.	.	.	*	.
robustus, Davis	.	.	.	.	.	.	*	.
Wardi, Davis	.	?	.	.	.	.	.	.
denticulatus, Davis...	.	*	.	.	.	.	.	.
(Diplodus.)								
gibbosus, Ag. (and others)	.	*	*	.	*	.	*	.
Compsacanthus, Newbury.								
triangularis, Davis	.	.	.	.	.	.	*	.
major, Davis	.	.	.	.	.	.	*	.
Ostracocanthus, Davis,								
dilatatus, Davis.	.	.	.	.	.	.	*	.
Pleurodus.								
affinis, Ag., Davis ...	.	*	*	.	*	*	.	.
Rankinii, Ag.	.	*	.	.	.	.	.	.
Helodus.								
simplex, Agass.	.	*	.	.	*	*	.	.
sp. (?)	.	*	.	.	*	.	.	.
Pœcilodus, sp. (?)	.	*	.	.	.	.	.	.
Harpacodus, sp. (?)..................	.	*	.	.	.	.	.	.
Petalodus.								
Hastingsiæ, Owen ...	.	*	*	.	*	.	.	.
Ctenoptychius.								
apicalis, Ag.	.	*	.	.	.	.	*	.
Cladodus.								
myrabilis, Agass.	.	*	.	.	*	.	.	.

⁂ The * indicates the presence of the species, &c.

The knowledge of the mode of life and of the habits of the fish, to be gleaned from a careful consideration of their distribution and deposition, and the zoological affinities of their living allies is, perhaps, not very extensive or decided, but there are a few facts which may be usefully remembered. The fish remains, in nearly every instance, are found on the surface of a bed of coal; instances rarely occur in which the remains of fish or other vertebrates have been discovered in the shales above the coal; in the sandstones no instance has been recorded. There is thus then, in every instance where they have been found, a peculiar aggregation of fishes, whose modern representatives are of both marine and freshwater types. Being associated in death, they must have lived together, and the question naturally follows as to whether the marine forms adapted themselves to the environment of the freshwater species or *vice-versa.* There is the further consideration, that though the recent fishes live, for the most part in their respective media, and are incapable of adapting themselves to a different one, this may not always have been the case, and it is equally possible that, during the deposition of the Coal Measures, the sharks may have been freshwater fishes or the Ganoids may have been marine. Amongst living fishes, the sharks are a large and numerous group, for the most part existing in the sea, but occasionally becoming more or less adapted to living in freshwater. It is well-known that sharks of large size ascend many rivers, such as the Ganges; the Saw-fish has been observed in many rivers of both Africa, Asia and the South Sea Islands, and sharks have been seen as far inland as Bagdad, in the river Euphrates, by Capt. Sleigh and others. There is also the instance narrated by the late Thos. Belt, of sharks inhabiting the lake Nicaragua in Central America, completely cut off from all communication with the sea. These cases prove that, even at the present time, the Elasmobranchs have the power to adapt themselves to living either in salt or freshwater. If we turn to Ganoids, we find that, with the exception of the Sturgeons, they are all freshwater fish, and do not possess any power or exhibit any inclination to migrate to the sea. The sturgeons live indiscriminately in either salt, brackish, or fresh water, but of all the Ganoid fish they are most unlike the fossil forms. Amongst the Siluroids and other Teleostean forms, it is not uncommon to find marine forms ascending rivers to spawn or in search of prey, but in no instance are the freshwater species known to leave their native habitat and descend to the sea.

During Carboniferous times, the most common and universal fish appears to have been *Megalichthys*, a Ganoid of large size, attaining four or five, or even eight to ten feet in rare instances, in length, protected by thick rhomboidal scales and plates of ganoine, with powerful jaws armed with large pointed teeth, evidently a predacious fish, feeding probably on its smaller associates. Along with *Megalichthys* there is frequently found a still larger Ganoid, *Rhizodus*, which has been found 16 or 18 feet in length, though the Yorkshire specimens are much smaller. In these Coal Measures it has only been found in one locality, above the Black-bed Coal near Bradford ; but in Scotland, at Gilmerton, it is of frequent occurrence, and teeth are in my collection which measure quite four inches in length, and scales of nearly the same diameter. The teeth and scales of *Strepsodus* (or *Holoptychius*) are generally found along with other fish remains in Yorkshire. The teeth of this fish have a peculiar twist towards the point, which readily distinguishes them from any other species; they frequently occur nearly or quite two inches in length. The scales appear to have been softer and more loosely attached to each other than is usually the case with Ganoids, resulting in their separation before becoming fossilized, consequently specimens are rarely found of more than single scales, though one slab of shale, about 16 inches by 10, covered with scales and a large operculum, seemingly in proper position, indicates that the fish must have been several feet in length. The remains of *Cœlacanthus* are very abundant in the Yorkshire Measures, decidedly the most frequent and characteristic fish of the period. In the Lower Coal Measures it is not so well preserved or so common as in those higher in the series. In the shale above the Better-bed Coal, it is never found entire, but the bones of the head indicate a fish about two feet in length. It is present in great abundance in the Cannel Coal, between Wakefield and Bradford, and is well and beautifully preserved. The specimens are of varied size, ranging from two or three inches to between 18 and 24 inches. Associated with these Ganoids were those of the genera *Acrolepis*, *Platysomus*, *Rhizodopsis*, and others which are occasionally found in exquisite preservation, but more frequently in fragments. One other Ganoid should be noticed. Though of comparatively rare occurrence in this coal-field, it is more frequently met with in others. *Ctenodus* is a genus closely allied to *Dipterus* of the Old Red Sandstone, and serves as the connecting link during the Carboniferous period between that genus and

Ceratodus, which still continues to exist. These, along with the recent *Lepidosiren* and *Protopterus*, form a peculiar group of fish with acutely lobate paired fins. Their internal organization allies them closely with the Ganoids, but they differ from the Ganoids in possessing a modified air-bladder, which enables them to breathe air, and so to exist out of water for long periods. These characters have been considered of sufficient importance by some naturalists to necessitate the creation of the Order Dipnoi for their accommodation; whilst others, taking their otherwise close resemblance to the Ganoids into account, place them as a branch of that Order. It is very probable that the latter may turn out their true position. The possession of an air-bladder, osseous or otherwise, is not restricted to these five genera, but is also to be found in many of the Siluroid Teleosteans, as well as the Lepidosteans and other Ganoids, and in the Sirenoid fishes of the rivers of South America.

Amongst the fishes comprised in the Elasmobranchii, the genera *Ctenacanthus* and *Gyracanthus* present features indicating that they attained to a very large size. The only known fossil parts of these fishes are the spines, analogous to those of the young dog-fish of our coasts, in which the spines are placed before each of the dorsal fins. Teeth and dermal tubercles have been at various times associated with the spines, but without conclusive proof that they belonged to the same genus of fishes. The spines of both genera are tolerably common, and occur in greater or less abundance in every stratum where fish remains have been found. They are sometimes as much as 2½ to 3 inches in diameter, and a couple of feet in length. Along their posterior surface there is a deep groove in which the fin was attached. Some of the spines are worn at their distal ends, and appear to have been attached to the pectoral fins. Being worn by rubbing against the bottom, they indicate fish which was a ground feeder, and accustomed to a position on or near the bottom.

Pleuracanthus (including *Orthacanthus*, Ag., *Diplodus*, Ag., and *Xenacanthus*, Beyr.), forms a large group, and is distributed over the whole series of the Coal Measures. Several new species have been found in addition to the *P. lævissimus*, *P. cylindricus*, and *P. gibbosus* of Agassiz. The whole series of about a dozen species is extremely interesting for many reasons which cannot be entered into at present. *Acanthodes* and *Lepracanthus* occur in the Lower Coal Measures in the Bone-bed above the Better-bed Coal,

and are not very rare. *Hoplonchus* and *Phricacanthus*, new genera, are also from the same bed. Several teeth, which are supposed to have belonged to Elasmobranch fishes, as *Cladodus Ctenoptychius*, *Petalodus*, *Pecilodus*, and *Helodus*, occur in some of the strata. *Compsacanthus*, a genus of fish, instituted by Dr. Newberry in the United States, with only one row of denticles along the dorsal aspect, and hitherto unknown in this country, is now represented by two species from the Cannel Coal. To the genus *Pleurodus* named, but not described, by Prof. Agassiz, the Yorkshire Coal Measures have rendered specimens affording information on which to base, not only a description of the teeth, but also of the spines. The fish was probably nine or ten inches long, very deep in the body, with a large gape and pavement-like teeth. At the highest point of the dorsal part of the fish, a smooth spine was implanted, broad at the base, but rapidly tapering to a point, and from two to three inches in length. The whole skeleton of the fish was cartilaginous.

One or two comparisons of the fish fauna of the Yorkshire Coal Field, with those of other parts of the country, may perhaps be useful. The principal supplies of fossil fish have hitherto been derived from the Scotch Coal Measures at Burdie House and Gilmerton ; from Newsham near Newcastle-on-Tyne (Low Main Coal-seam) ; from the Ironstone shales of North Staffordshire, and from the Coal Measures of the West Riding of Yorkshire. Several of the Lancashire beds have yielded fish remains, notably the Arley mine, but not in such numbers or of sufficient diversity to render them of peculiar interest. Considered in relation to the other sources mentioned, the Yorkshire fossils are peculiar for the great number of genera and species, as well as individuals of fossil spines. The genera *Gyracanthus* and *Ctenacanthus* are common to all the localities, occurring in greater or less abundance, but the genus *Lepracanthus*, many of the species of *Pleuracanthus*, the genera *Phricacanthus*, *Hoplonchus* and *Compsacanthus*, have hitherto been peculiar to the Yorkshire Coal Field. The great abundance of *Cœlacanthus* may be also considered a peculiarity of this district, for though the fish is found in Staffordshire and elsewhere, it is comparatively rare.

The Staffordshire district has been particularly rich in species of small Ganoids. *Palæoniscus* (*Elonichthys*), which occurs in Yorkshire very sparingly, if at all, is extremely abundant and well-

preserved. The genera *Platysoma*, *Cycloptychius*, *Acanthodes*, and *Amphicentrum* are all well represented, as well as several others.

The Newcastle district is remarkable for the number and preservation of several species of *Ctenodus*, whilst *Palæoniscus* is rare, and the spines so common in Yorkshire are absent. A larger proportion of Labyrinthodonts are found intermingled with fish remains in this coal-field than in any other, whilst on the other side of the Tweed, the principal feature of the fish fauna rests in the presence of immense Ganoids of the genus *Rhizodus*. These fishes, armour-plated, and possessing strong jaws, armed with immense teeth measuring three or four inches in length, must have been most formidable adversaries to all other existing species. In no other district is the *Rhizodus* developed to so large a size as in the South Scotch Coal Field.

Thus we find that, whilst certain of the fishes are common to all the districts, like *Megalichthys*, *Gyracanthus* and *Ctenacanthus*, there are others which were altogether localized, or which thrived much better in some localities than in others. It will be an interesting work, when sufficient material shall have been accumulated from all these districts, to consider on what special features these diversities of fauna depend, and to endeavour to elucidate by these means the physical history of the Carboniferous Period.

EXCURSION TO KEW GARDENS, RICHMOND, AND KINGSTON HILL.

SATURDAY, JUNE 12th, 1880.

Directors:—SIR JOSEPH D. HOOKER, C.B., F.R.S., &c., Director of Kew Gardens; and J. LOGAN LOBLEY, ESQ., F.G.S.

A numerous body of Members and friends assembled at the grand entrance of the Royal Gardens of Kew, and were met by Sir J. D. Hooker, who conducted the party through several of the houses and the most interesting parts of the gardens. The more noteworthy of the plants were pointed out, and the most remarkable were the subjects of special demonstrations, which were listened to with great interest. After the visitors had inspected the new Temperate House, on the west of the Grand Avenue, Prof. Morris,

in proposing a vote of thanks to Sir Joseph Hooker, enlarged upon the geological interest of many of the plants that had been seen, particularly referring to those which illustrated the vegetation of the Carboniferous Epoch.

On leaving the gardens Mr. Lobley conducted the party by Richmond Green, the old tilting yard of the great historical palace of Richmond, or Sheen, as it was in olden times called, to the "Hill," where, with the Survey maps of the district spread on the ground, the physical features of the portion of the Thames Valley, seen from this commanding eminence, were pointed out. Though the atmosphere was not very clear, the towers of Windsor, marking the commencement of the Western Chalk, were made out, but the elevations of London Clay, on the north side of the valley, could not be seen. The steep declivity of Richmond Hill, and the somewhat elevated and undulating country on the Surrey side of the valley in this district, is in marked contrast to the extensive low plain which forms a considerable portion of the County of Middlesex on the other side of the river. The higher land on the Surrey side is London Clay, covered, for the most part, by High-level Gravels, and in some places by Bagshots, while the low lands of Middlesex present an almost unbroken sheet of Low-level Gravels and Brick-earths covering London Clay. These Brick-earths are most extensively worked along the Great Western Railway in the neighbourhood of Southall and other places. To those who have seen and admired the magnificent beech-woods which grow on the Chalk hills higher up the Thames Valley, the stately elms which flourish on the Alluvium and Brick-earths of this neighbourhood, and the noble oaks of the higher grounds, present a strikingly different scene.

Proceeding through the Park, the party were several times tempted to stop and admire its sylvan beauty, but a gravel pit, near the Thatched House Lodge, claimed attention to an interesting indication of the presence of the Lower Bagshots. Another outlier of these beds was passed on Kingston Hill, where an old pottery affords a somewhat unsatisfactory exposure.

Higher up the hill, and near the "George and Dragon," an extensive excavation displays a very fine section of the High-level Gravels, which were examined with great interest, and explained by the Director, who drew attention to the presence of pebbles derived from various and distant rocks, although the great bulk of the gravel is composed of sub-angular and rounded flint from the

Chalk. Ragstone and chert pebbles from the Greensands are common, while white quartz sub-angular pebbles are by no means rare, and others are met with which are doubtless from Silurian rocks. After discussing the possible means by which fragments of such different rocks were brought together and deposited in this district in such great quantity, the party proceeded by Coombe Valley, crossing to the opposite elevation, the Ridgway, which was followed to Wimbledon, where the train was taken for London.

EXCURSION TO CROYDON AND RIDDLESDOWN.

SATURDAY, JUNE 19th, 1880.

Director:—J. LOGAN LOBLEY, ESQ., F.G.S.

On arriving at East Croydon station the Members of the Association were met by John Flower, Esq., M.A., and a party of Members of the Croydon Microscopical and Natural History Club, of which that gentleman is the President. The well-known extensive gravel-pits in Fairfield were first visited, and the fine sections of Valley gravels here exposed were carefully inspected. The Director and Mr. Flower explained the sections, and drew attention to the presence of the Oldhaven pebbles, so abundant now at Shirley and Croham Hurst, and to the course of the Wandle having changed so considerably as to leave here high and dry about twenty feet thickness of its old deposit. Mr. Flower was not aware of any organic remains having been found here, but at Thornton Heath an elephant's tusk, preserved by a coating of clay, had been obtained.

The underlying Woolwich and Reading Beds are not now exposed as formerly in Chichester Road, but the presence of their clay-beds is indicated by springs and the lake in the beautiful grounds of Park Hill House, the residence of Mrs. J. W. Flower, which the party was courteously invited to visit. From Park Hill to the Water Tower is but a short walk, and, by the kindness of Dr. Strong, of Croydon, the whole of the party were enabled to assemble on the top of this commandingly placed building. The day being fine the physical features of the district were seen to advantage; the hills of Shirley and Croham Hurst, and the Ban-

stead Chalk Downs rising boldly to the south and west, and on the north the great valley of the Thames running from west to east.

At the foot of Water Tower Hill a very interesting section shows the thinning out of the Thanet Sands almost to a feather edge, resting as usual on the Chalk with green-coated flints atop. There is thus seen the extreme southern edge of the London Tertiary Basin.

Croham Hurst, a mile to the south, was next visited. The summit of this hill, 477 feet above the sea level, is an outlier of Tertiary (Oldhaven) Beds, the well-rounded blue-black pebbles of which, by rolling down, cover a considerable part of the steep slopes. So steep indeed is one side that it is called Breakneck Hill, but this the geologists descended safely, and made their way by the Brighton Road, to the chalk-pit opposite to the "Royal Oak," famed for the granite boulder once found in it and attributed to ice action in the Cretaceous Period.

The party subsequently proceeded—by way of Purley—to Riddlesdown, skirting the fine Chalk valley of Kenley, along which, after exceptionally wet seasons, the Bourne river flows. After the sections of the Chalk exposed in the excavations along the hill had been seen, and refreshments obtained at the "Rose and Crown," the train for London was taken at Warlingham station.

EXCURSION TO REDHILL.

SATURDAY, 26th JUNE, 1880.

Director: C. J. A. MEYER, ESQ., F.G.S.

(*Report by* THE DIRECTOR.)

The Fuller's-earth beds in the Lower Greensand in the vicinity of Redhill and Nutfield formed the principal point of interest in this excursion. The strata yielding fuller's-earth in workable quantity occupy the northern slope of the sand-ridge between Redhill and Bletchingley. The position in the Cretaceous series of these particular fuller's-earth beds has been long a matter of uncertainty amongst geologists, some observers placing them in the Hythe Beds, others in the Sandgate Beds of the Lower Greensand. It was on this occasion pointed out and explained to the Members present that the fuller's-earth beds of Nutfield really

belonged to, and represented in position, a part of the Folkestone Beds of the Lower Greensand. It was explained that the typical Folkestone Beds, as existing at Folkestone and between Folkestone and Sandgate, consisted throughout their whole thickness of alternations of stone, sand, and sandy clay. These Folkestone Beds proper *westward* of Folkestone took on, however, in their upper part, a constantly increasing thickness of pure sand beds. These sand beds, which consisted of white and iron-stained sand, with "carstone" and occasional thin partings of fuller's-earth, had a thickness near Maidstone of about thirty feet. Near Reigate their thickness was about ninety feet. Further westward, near Guildford, their thickness was not less than 130 feet. At Shanklin, in the Isle of Wight, their thickness probably exceeded 200 feet. Unlike the typical Folkestone Beds, these overlying sand beds were unfossiliferous. Wanting at Folkestone, they were westward of Folkestone interposed between the Gault and the Folkestone Beds proper. The fuller's-earth and accompanying stone beds occupying the northern slope and crest of the sand ridge between Redhill and Bletchingley were thus shown to represent the true Folkestone Beds, and that representatives of the Sandgate Beds and Hythe Beds of the Lower Greensand occupied the southern escarpment only of the same sand ridge.

ORDINARY MEETING.

July 2nd, 1880.

W. H. Hudleston, Esq., M.A., F.G.S., Vice-President, in the Chair.

The Donations received since the previous meeting were announced, and the donors received the thanks of the Association.

The following were elected Members of the Association :—

J. L. Black, Esq.; Miss Emily Hubbard; Dr. Mansell MacCulloch; A. H. Scott White, Esq., B.A., B.Sc., F.G.S., F.C.S.

The following Paper was read :—

On the Geology of the Bristol District.

By Prof. W. J. Sollas, M.A., F.R.S.E., F.G.S., &c.

Geologists possess, in the Survey Memoir, by Mr. H. B. Woodward, a complete handbook to this neighbourhood. In it descriptions of the localities which the excursion will visit are given in full detail; to repeat them here would be a work of supererogation, and, consequently, I shall only attempt in this paper to present a sketch in broad outline of the geological history of the neighbourhood.

The earliest rocks which we shall examine are the Old Red Sandstone, exposed on the summit of the Mendips, and in the cliff from Portishead to Clevedon; they were deposited in an area of depression which was formed after the great post-Cambrian and pre-Silurian folding of our country, and which extended from the Cambrian rocks of Wales on the west and north, to the line of Malverns on the east, and the Bristol Channel on the south. Outside the two latter boundaries was the basin in which the Devonian rocks were contemporaneously deposited to the east and south.

The lowest beds of the formation are chiefly *red marls* and shales which lie conformably on the older Silurian strata; above these beds we find *red sandstones*, with red marls and cornstones, and above these *conglomerates* with red marls and sandstones, which form the highest beds of the formation, and pass conformably into the Carboniferous Shales, as may be seen below Cook's Folly in the Avon section. The passage from marls through sandstone into conglomerates shows that the basin was becoming shallower, owing, probably, to deposition proceeding at a more rapid rate than depression, the succession of the Lower Limestone Shales over the Old Red Sandstone shows, on the other hand, that depression was taking place at that time faster than deposition could keep pace with it, and this relation (depression greater than deposition) appears to have continued into the Carboniferous Limestone times.

The Cambrian and pre-Cambrian rocks, which furnished sediments for the Old Red Sandstone, consisted of arenaceous, argillaceous, and calcareous strata, together with various intrusive and erupted igneous rocks. The origin of the ordinary sedimentary rocks of the Old Red Sandstone, such as sandstones, marls, and conglome-

rates, presents us with no difficulty; not so, however, the red oxide of iron, to which it owes its colour, and the layers of "cornstone" or nodular limestone which characterise the lower and middle parts of it. The cornstones are clearly inorganic, and have probably been formed by the mechanical denudation and re-deposition of pre-Silurian limestone beds. The ferric oxide may have been derived in part from the older red Cambrian beds, in part from the oxidised soil of igneous rocks, and in part from carbonate of iron introduced in solution by the action of decaying vegetation, and subsequently converted, by the loss of carbonic acid and the addition of oxygen, into peroxide of iron, which was precipitated in the Old Red Sandstone sea.

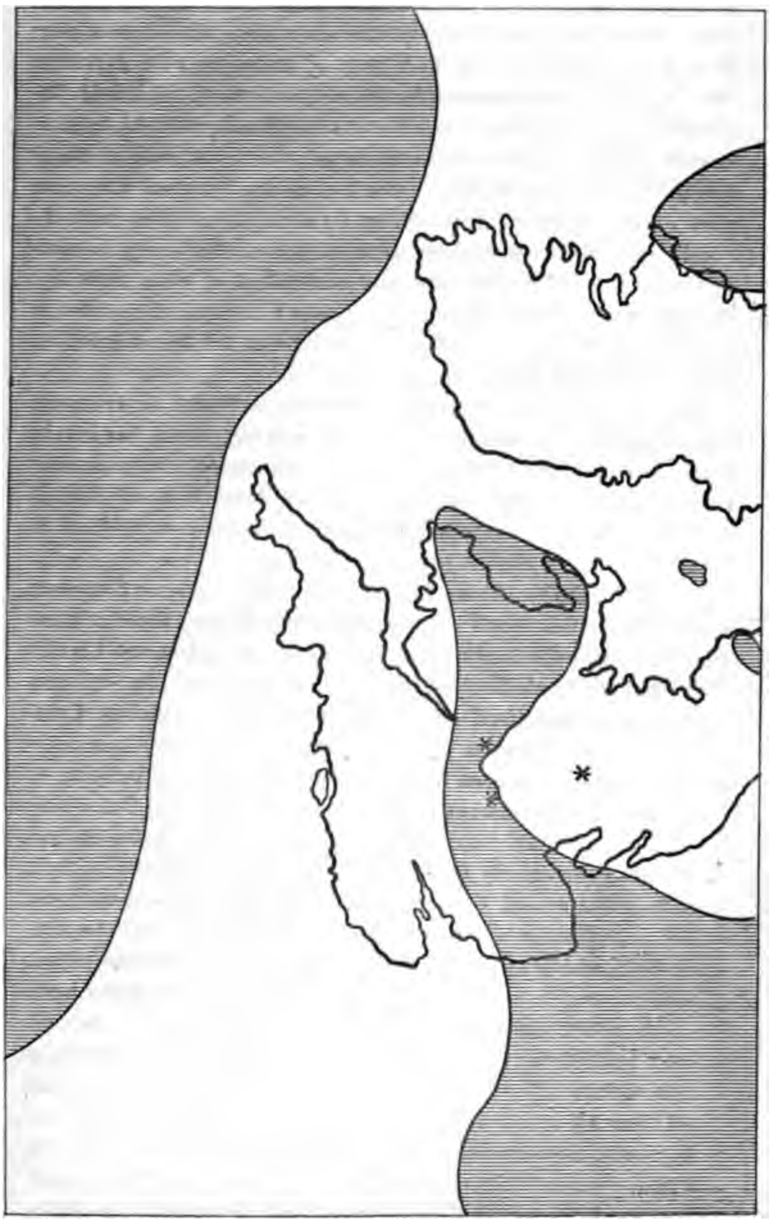
No fossils have been found in the Old Red Sandstone of this area, except the fishes *Holoptychius* and *Coccosteus*, of which scales and bones have been discovered near Portishead. To them, however, great interest attaches, and especially to *Holoptychius*, which resembled the existing *Ceratodus*, a fish showing strong tendencies towards the Amphibian type. Probably *Holoptychius*, if not in the direct line with, was at all events, closely related to, the forms from which the Amphibians of the succeeding formation were derived.

The Carboniferous formation in this area consists of the following members, the thickness of which, in the Bristol Coal-field and the Avon section, is given in feet:—

Coal Measures	5,000
Millstone Grit	1,000
Carboniferous Limestone . . .	2,500
Lower Limestone Shales . . .	500
	9,000

The area (Fig. 1), in which it was deposited was the outcome of that of the Old Red Sandstone, modified by the general depression which it had undergone, and by various local changes of level, including both elevation and depression. It was bounded on the north by the now well-known central peninsula which stretched across the middle of England; Newent on the Malverns, and Haverfordwest, South Wales, being two points on the southern coast of the peninsula. On the south it was bordered by a continent, the northern coast-line of which passed somewhere through the north-east of France, and

FIG 1.



near the South of Cornwall and the South of Ireland. The South of England basin was in free communication with a wider European one. During a period of exceptional depression, the sea was clear though by no means deep, and beds of limestone were deposited over nearly its whole extent. In this neighbourhood thick field-like growths of encrinites and rich banks of molluscs produced, by their growth and decay, the lower parts of the limestone; these at length yielded to a luxurious growth of corals, by which the upper part of the limestone was chiefly formed. Associated with the coralliferous beds are thick deposits of oolite, which may be seen in the Avon section, and thus the association of coral reefs and oolitic deposits which exists at the present day, which existed in the Silurian period, and is so characteristic of the Jurassic formation, is again met with here.

The quiet growth of the limestone was interrupted on one occasion at least by an episode of igneous activity, which has left its traces in the thick beds of volcanic ash associated with once vesicular but now amygdaloidal basaltic lava, to be seen interbedded in the limestone along the coast-section from Weston-super-Mare to Swallow Cliff.

While the Carboniferous Limestone was forming over Somerset, a great river which I shall venture to call De la Bêche's River, as those which entered the basin of the North of England may be termed Hull's River and Phillips's River, flowed through the great southern continent and emptied itself into our basin somewhere south of Cornwall and Devon; it soon brought to an end the conditions under which limestone had been formed over those counties, building up by its deposit of sediment the great thickness of the Culm Measures. This continued accumulation of sediment brought the mouth of the river continually farther and farther north, till at length its delta began to spread its seaward margin over Somerset and South Wales. Deposition was now in excess of depression, and the Millstone Grit, with its thin bands of limestone and marine fossils (*Producta scrobicula*, &c.), is the first sign of that enlargement of the delta which culminated in its extension over the whole of the western part of the South English basin. On the alluvial plains or deltaic flats so formed, the Carboniferous vegetation extended itself from adjacent lands. The spores and *débris* from the Lycopods, Ferns, Equisetums and Conifers accumulated on the ground, and in the warm, moist climate, formed a fermenting mass, which both served as a hotbed, stimulating the germination of fallen

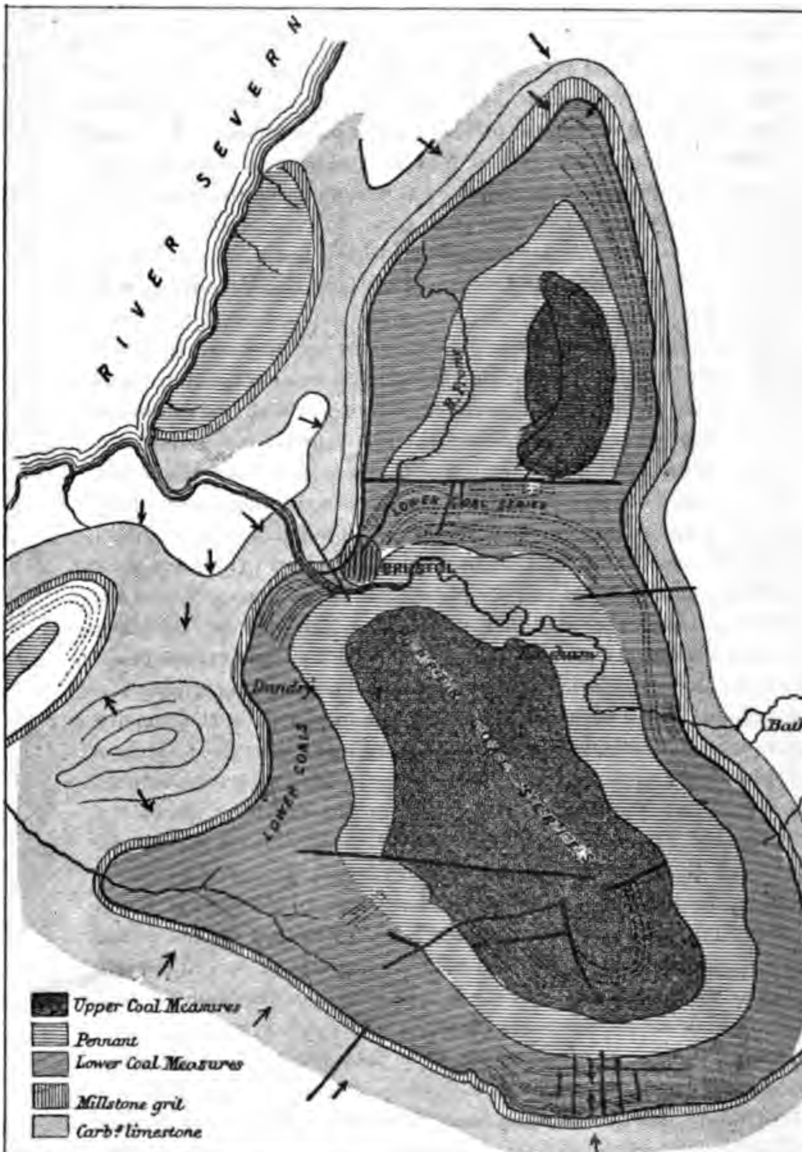
spores, and led to such a complete decay of woody tissue as sufficed to obliterate nearly every trace of its structure. The more resinous spores and the bark of the trees resisted decay better, and are more frequently preserved.

Wide tracts of the decayed and fermented mass were quietly depressed beneath the water-level; shales and sands were strewn over it, and so far *one* coal-bed was completed. Deposition continued in excess of depression till a fresh land-surface arose, and a fresh coal supply was laid down; depression again ensued, and this series of processes was repeated as many times at least as there are coal beds (44) in our coal-field.

At length the great geosynclinal which had been in progress throughout the whole of the Silurian, Old Red Sandstone, and Carboniferous times, and which extended from Ireland into Belgium and Germany, was complete; tremendous pressure then set in from the South, and in the basin of the South and West of England thrust the great mass of Siluro-Carboniferous deposits against the buttresses afforded by the Pre-Silurian rocks of Wales on the West and North, and the Malvern range on the East. Thus, from an approximately horizontal position, they were folded up into great rolling curves (synclinals and anticlinals), sometimes sharply curved and even bent back on to themselves (reversed anticlinals), and fractured and displaced (faults both normal and reversed). The synclinals, or rather basins, exist now as the South Wales, Forest of Dean, Bristol, (Fig. 2,) Nailsea, and various other coal-fields, most of which are now concealed under newer strata; the anticlinals which separate the basins are to be seen in the Mendip range, which extends from Frome on the east to the Steep Holme on the west; in Broadfield Down which extends westwards to Swallow Cliff and the Flat Holme;[9] and in the curved ridge of the Durdham, Clifton, and Leigh Downs. Had these anticlinals attained their full height above the sea-level, unworn by denudation, they would, in some cases, have risen to a height of 8,000 to 10,000 feet above their present level. But they did not escape denudation, for this is the universal concomitant of elevation; and just as we have always to bear in mind the movements of the sea-floor which accompany sedimentation, so we must always, in considering the result of elevation, take into account the opposing action of denudation. As the Mendip and its fellow anticlinals rose slowly into the air, they were incessantly acted upon by subaërial denuding agents; rain and rivers did their worst upon them,

FIG. 2.

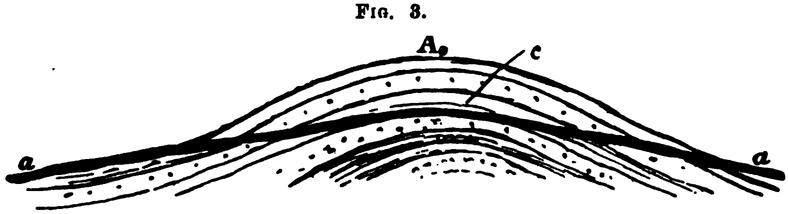
SOMERSETSHIRE COAL-FIELD AFTER THE POST-CARBONIFEROUS DENUDATION.



cutting out valleys, and leaving the intervening land between in steep hills and ridges, to attest, by surviving it, the waste which the surrounding country had undergone. The anticlinals, however much they might suffer, would clearly not in this way be worn down to any uniform or nearly horizontal plain; that is the work of the sea, it is the one great leveller. The waves produced by their incessant abrading action the ordinary features of a coast-line around the elevated Siluro-Carboniferous land. Lofty cliffs bore witness to the extent of the land which had been destroyed and the beaches at their base lay over the first beginnings of a plain of marine denudation. After the anticlinals had been sculptured into contour by rain and rivers, and outlined into configuration by the sea, a long-continued depression ensued, the sea-cliffs were more rapidly undermined and swept away by the power which had produced them; the valleys formed arms of the sea, the hills headlands which were continually undermined and sliced away. The sea completed the work which rain and rivers had commenced, the broad and lofty anticlinals disappeared, and a wide sea rolled over the cut-off edges of the strata which had formed them.

The depression of the land not only accelerated the work of marine denudation, but it determined the main slopes of the plain of marine erosion, for, by the time the highest land had been destroyed and its remains submerged, the lower was out of reach of destruction far beneath the sea-level. Thus the denuded surface of the land would really be a sloping one, having for its maximum height a line corresponding in general direction with the line of maximum height of the largest original anticlinal, but some thousands of feet below it. This will be rendered clearer by the following diagram:—

FIG. 3.

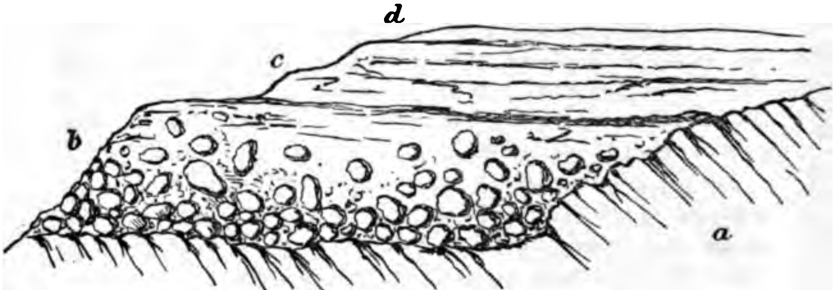


a, a, plain of marine denudation, having its maximum height at *c*, immediately below the summit *A* of the original fold.

Thus great as is the power of denudation in its various forms, it is

quite incompetent to efface some of the more important features which are first impressed upon the land by the power of elevation. On the sloping plain of marine denudation sediments were laid down, the ruined sea-cliffs ground to pebbles and powder, furnished beaches which followed close upon the sea as it stole across the land. These beaches are known to us now as the Magnesian conglomerates of the Trias, and thus the elevation of the Siluro-Carboniferous strata and the commencement of their depression occurred between the end of the Carboniferous and the beginning of the Triassic times. The Trias beaches may be easily examined on the side of the new road from the Downs, where there is one consisting of rounded boulders of limestone, some of which are several feet in diameter, (Fig 4); and

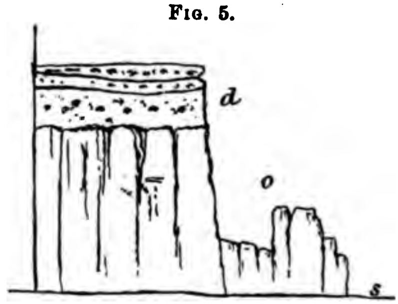
FIG. 4.



a a. Bed of Carboniferous Limestone at base of Lower Grit, brought down by a fault on the north of Observatory Hill.
b. Boulders and Pebbles (in part subangular) of Carboniferous Limestone and Grit, some of the boulders not much less than three tons in weight, cemented by feruginous and calcareous matter.
c. Conglomerate or breccia containing more of the calcareous component.
d. Calcareous component still more in excess.

along the cliff section, from Portishead to Clevedon, (Fig. 5,) where they form a breccia of limestone fragments as sharply angular as when they first fell from their parent cliff into the sea; while some retain the slickensided surface of the jointed limestone which furnished them as fresh as if embedded yesterday.

FIG. 5.



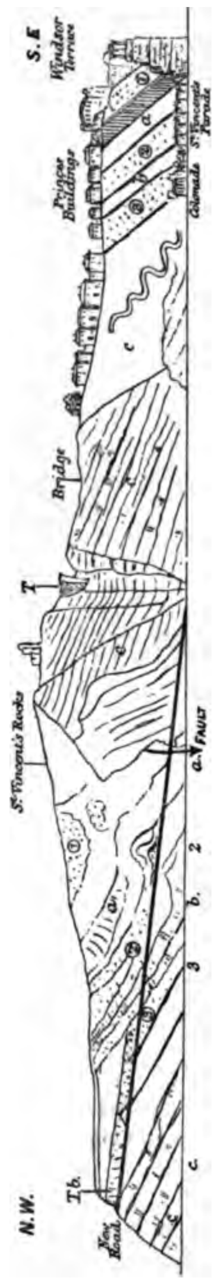
d. Dolomitic conglomerate.
o. Old Red Sandstone.
s. Shore.

On the Clifton side of the Avon section, some of this beach material is seen as a dyke in the Carboniferous Limestone, having filled in an open joint which was revealed by the great post-Carboniferous denudation (Fig. 6, T.) We may now proceed to give an account of the Triassic sea as it was when fully established by long-continued depression.

The British Trias was laid down in an inland sea, which covered the centre of England, and extended thence in three great processes, N.E., N.W. and S.W. (Fig. 7.) The S.W. gulf, which alone concerns us, was connected with the central sea through the Malvern Straits; on the west it was bounded by the Palæozoic land of Wales, Devonshire and Cornwall, into which it thrust two long arms westwards, one over the site of the Bristol Channel and the other along the middle line of the great Devonshire synclinal; on the north and north-east it was bounded by the Palæozoic axis of London and Harwich, and on the south by some great land now unknown to us. This inland sea was probably at one time in communication with the main ocean, but for the most part it was completely isolated from it. Swept by dry winds, it suffered excessive evaporation, its waters

Fig. 6.

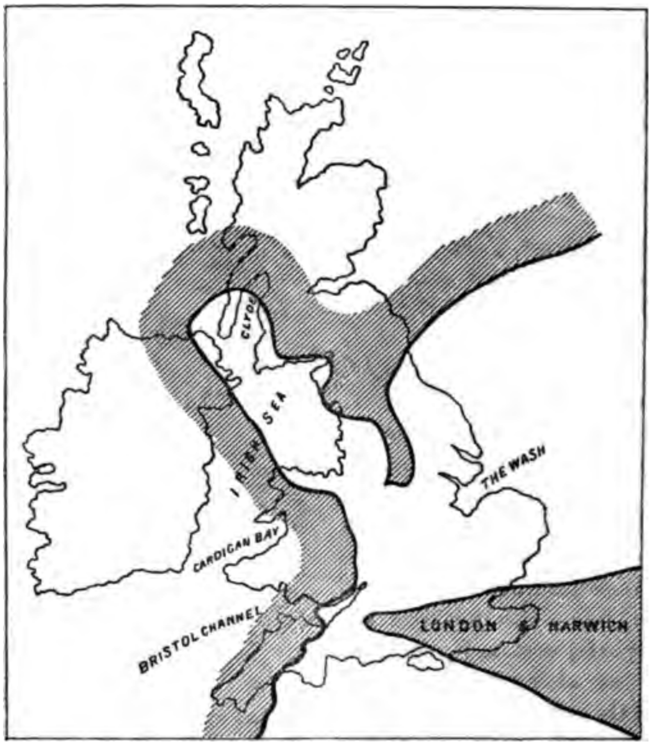
SECTION ALONG THE RIGHT BANK OF THE RIVER AVON, SHOWING THE STRUCTURE OF CLIFTON DOWNS.



1. Millstone Grit. 3. Lower Grit. b. Middle Limestone. T. Trias Dyke.
2. Middle Grit. a. Upper Limestone. c. Great Limestone. T. b. Trias Conglomerate.

diminished in volume and became highly concentrated; but whether in this area rock-salt was deposited in consequence we have here no certain proof, though much indirect evidence.*

FIG. 7.

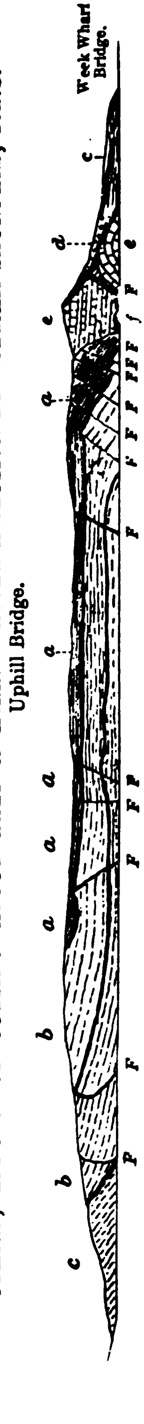


Gypsum, however, crystallised out in abundance, and may be picked out in various forms from Aust Cliff. On the continent to which this vast inland lake belonged, there lived a varied fauna, the ancestors of the higher Vertebrata, and the descendants of the pro-Reptilia of Carboniferous times; there were reptiles which had branched off into ornithic forms, and others which had become true ostrich-like birds, and there were other reptiles more nearly in the right path, which had branched off into mammalian forms, and given rise to Monotremes and Marsupials. In our area

* Since writing this I have seen specimens of marl from Aust Cliff, bearing pseudomorphs of rock-salt—an unexpected piece of direct evidence.

FIG. 8.

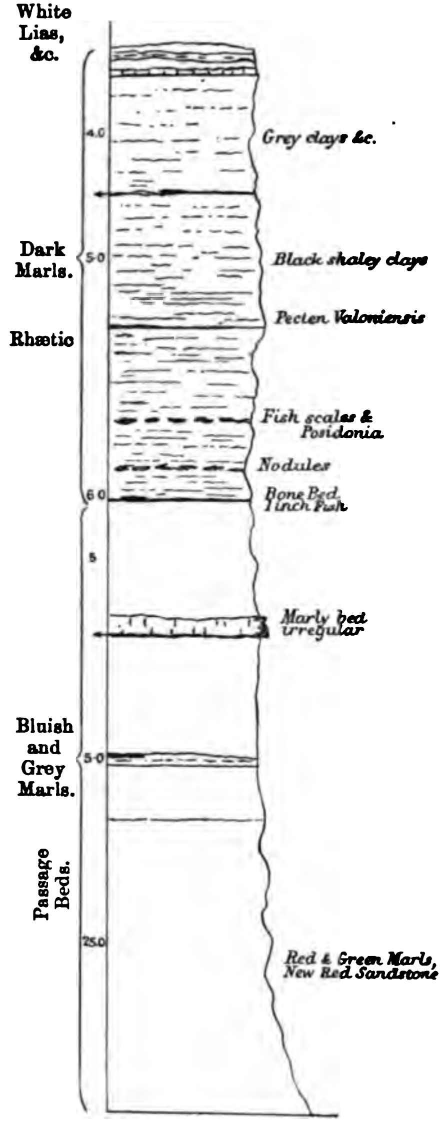
UPHILL, LENGTH OF CUTTING ABOUT HALF A MILE. AFTER A SECTION BY WILLIAM SAUNDERS, F.R.S.



a. Lower Lias. b. Penarth Beds. c. Red Marl. d. Dolomitic Conglomerate. e. Carboniferous Limestone. f. Trap Beds. F. Fault.

FIG. 9.

UPHILL SECTION.

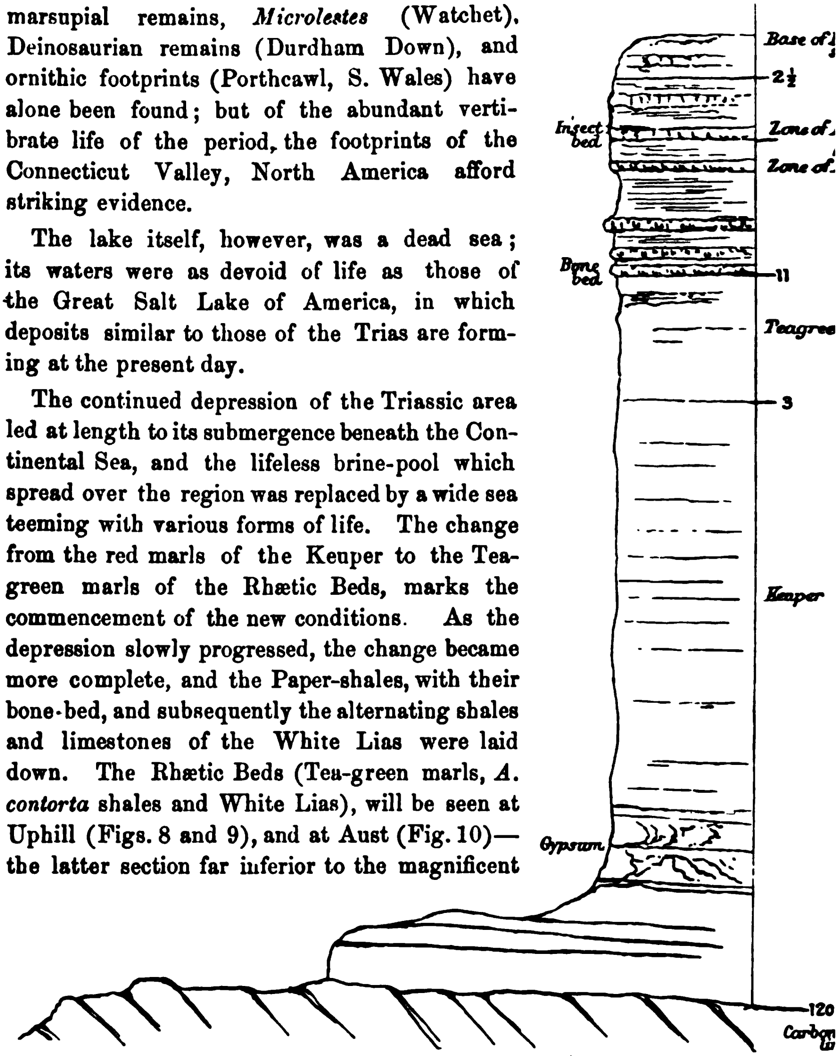


marsupial remains, *Microlestes* (Watchet). Deinosaurian remains (Durdham Down), and ornithic footprints (Porthcawl, S. Wales) have alone been found; but of the abundant vertibrate life of the period, the footprints of the Connecticut Valley, North America afford striking evidence.

The lake itself, however, was a dead sea; its waters were as devoid of life as those of the Great Salt Lake of America, in which deposits similar to those of the Trias are forming at the present day.

The continued depression of the Triassic area led at length to its submergence beneath the Continental Sea, and the lifeless brine-pool which spread over the region was replaced by a wide sea teeming with various forms of life. The change from the red marls of the Keuper to the Tea-green marls of the Rhætic Beds, marks the commencement of the new conditions. As the depression slowly progressed, the change became more complete, and the Paper-shales, with their bone-bed, and subsequently the alternating shales and limestones of the White Lias were laid down. The Rhætic Beds (Tea-green marls, *A. contorta* shales and White Lias), will be seen at Uphill (Figs. 8 and 9), and at Aust (Fig. 10)—the latter section far inferior to the magnificent

FIG. 10.



SECTION OF AUST CLIFF.

exposure along the shores at Penarth, south of Cardiff, but of great inte being the source of the unique collection of *Ceratodus* teeth, which are presei the Bristol Museum.

Nowhere in our locality do the Rhætic Beds approach 100ft. in thickness, and yet their contained fauna leads us to correlate them with the Upper St. Cassian beds which, in the Rhætian Alps, attain a thickness of some 3,000 or 4,000 feet. The latter were deposited at a great distance from the land in a more rapidly subsiding area; the English beds near the coast-line of the sea, over a sea-bottom which sunk forty times more slowly. The depression which led to the planing across of the Carboniferous rocks and to the deposition of the Trias and the Rhætic, continued throughout the whole of the Liassic and a part of the Oolitic period, and so a mass of sediment, continuous from the Trias to the Inferior Oolite, buried the Carboniferous rocks out of sight, and formed far above the old plain of denudation, a plain of deposition which swept from the east of England away west, to end against the lofty hills of Wales. At length, near the close of the Jurassic period, elevation set in, pressure came from the east, and forced the Jurassic rocks against the Welsh buttresses on the west; a low anticlinal resulted, with its axis, in this region, situated over the eastern edge of the Bristol Coal-field, and having a long gentle slope to the S.E., and a shorter, perhaps steeper, slope to the W. This anticlinal was then subjected to denudation, and rolled pebbles were carried from it into the Wealden delta during the Neocomian period; afterwards it was depressed, and the waters of the Upper Neocomian sea began to cut a plain of marine denudation across it. The Cretaceous sea completed the work which the Neocomian had begun, and deposited its sediments over the denuded plain; nor can one doubt on looking east towards the Chalk hill of Long Knoll, near Maiden Braidley, that the higher beds of the Cretaceous must originally have extended right over the Oolitic rocks of this locality, and have crossed, in all probability, the Bristol Channel to abut against the east of Wales. In Tertiary times great crust movements again occurred, and led to the formation of a low anticlinal of Cretaceous rocks, similar in character to that of the previous and Oolitic anticlinal. Between the western face of this anticlinal and the older rocks of Wales, lay the depression of the Bristol Channel; down this western face, which formed the short steep slope of the anticlinal, the rivers of our district began to flow towards the West, and emptied themselves into the trough of the Bristol Channel—one of these rivers being the Avon. Two escarpments were formed—one at right angles to the dip of those

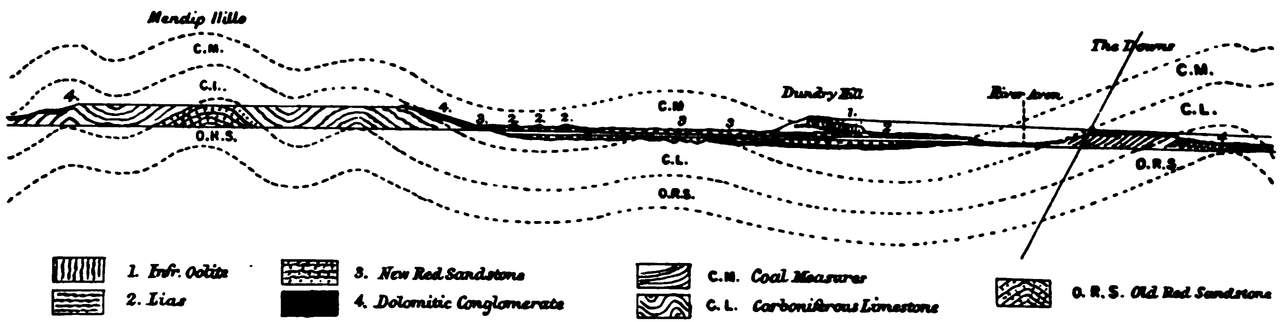
beds having the steeper westward slope, the other of those having the gentler eastward dip. The small patch of Cretaceous rocks at the west was soon removed, and so completely that not a vestige of it remains in our area; the escarpment on the east receded more slowly, but still has made considerable progress. The Oolitic rocks thus became subsequently exposed, and likewise gave rise to two escarpments; that on the west has almost entirely but not quite been destroyed; and patches of Inferior Oolite (Dundry Hill, 760 feet above sea level), and Lias still remain as outliers over our coal-field to assure us of their former wide extension, which otherwise we might have been tempted to regard as a mere dream of the imagination. The Trias remains as a wide-spreading sheet or sheets, which cover up and conceal the greater part of our coal-field, but enough has been removed to reveal to us in places the main features of the old Carboniferous plain of marine denudation (Fig. 11). Before alluding to this, however, it may be as well to point out that the river Avon, which commenced to flow down the steeper side of the Cretaceous anticlinal westwards, succeeded in cutting its way through the Chalk, Oolite, Trias, and finally entered the Carboniferous strata, wearing out for itself a channel which was broad in the softer and narrower in the harder rocks. Subsequent to the formation of its bed, and while it was being gradually deepened, the Mesozoic rocks were removed, and finally the Coal Measures on the east of the Clifton limestone were denuded away over a wide area down to the level of the river-side. Thus the low-lying plain east of the Clifton gorge was formed after the gorge itself, and this is the reason why the Avon, instead of flowing over this plain and emptying itself into the sea at Nailsea, flows through the higher country of the Downs by a gorge which, at first sight looks as though it had been specially prepared for its passage. It will do no harm to repeat that the low-lying ground to the east of the gorge was high-lying ground at one time, which directed the Avon right athwart the hard Carboniferous Limestone. When it had done this, and so led to the formation of the gorge, it was removed by general atmospheric denudation, and the gorge, left without its scaffolding, became as great a puzzle to the unscientific as the bridge which spans it was to a thoughtful American, who conjectured that it had been elevated by balloons!

Reverting to the main features of the old Carboniferous plain of marine denudation, as revealed by the later waste, which has

FIG. 11.

SECTION ACROSS THE MENDIP HILLS TO A POINT EAST OF THE CLIFTON DOWNS—19 MILES.

(REDUCED FROM A SECTION BY PROFESSOR RAMSAY).



The dotted lines above the section represent that part of the strata which was removed by the Post-Carboniferous Denudation. Those below, the extension of the strata beneath the ground. The straight line drawn from Dundry over the Downs represents the former extension of the Inferior Oolite in that direction.

stripped it of a good deal of its Mesozoic covering, one may point out first that its line of greatest altitude lies (as theory would predict) somewhere along the summit of the Mendip ridge, and that thence it slopes away on every side towards the sea. Standing on Walton Down, and looking south, the tops of Carboniferous Limestone hills can be clearly seen reaching up to a straight line which dips evenly downwards from the Mendip and Broad Down range to the top of the Steep Holme, thence to the Flat Holme, and still further west till, as we know, it ends below the Trias of Penarth, and then rises again north and west, to culminate in the Vans of Brecon and Caermarthenshire. Thus as a whole, and as it exists now, this plain of marine denudation may be said to slope from the Mendips westwards to the Bristol Channel, and then to rise again into the hills of Wales.

The depression of the Bristol Channel would thus seem to have been marked out before Triassic times.

But we have now to guard against a misconception involved in our use of terms; the plain of denudation can only be so regarded by a very liberal interpretation of the meaning of the term "plain," for it was excavated in some places into great hollows, and in others rose up into swelling prominences. These irregularities are clearly shown by the variations in the level of the base of the scattered patches of Trias on the older rocks; thus, not to go far from Bristol, the Trias of Durdham Down rests upon a limestone surface 200 feet above the river Avon. At Pyle, two or three miles west, the Trias rests on the Old Red Sandstone, not many feet above the river, and whilst the line from the Mendips to the summit of the Steep Holme (Carboniferous Limestone) lies from 1,000 feet to 200 feet above the sea level, the Trias from Clevedon to Portishead descends almost to the sea level. The irregularities so proved may have been produced at the same time as the plain of marine denudation, though some may have been caused by subsequent earth movements which, acting along the old axis of elevation, exaggerated the foldings which had been previously produced.

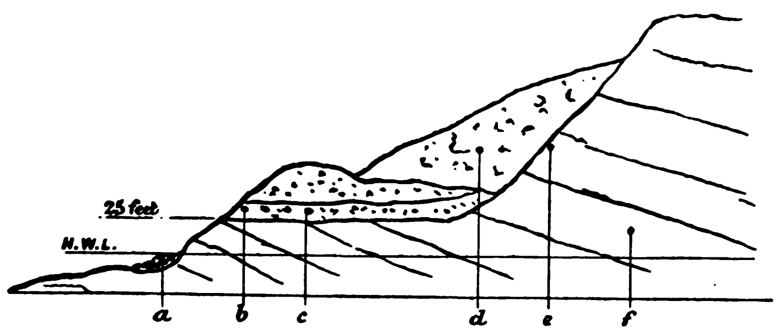
To return to the post-Cretaceous denudation, after the Bristol Channel had been established, and the Avon and its parallel rivers or "pills," as they are locally termed, flowed west, the scenery of our area acquired its present character; but during the period of Palæolithic man, the country stood much higher above the sea

than it does now ; the Avon gorge, in common with the rest of the district, was 600 feet higher above the sea level than at present, and the Bristol Channel formed a wide and fertile valley, watered by the ancient Severn.

Subsequently great depression ensued, one by one the six hundred feet by which the country had, in Palæolithic times, surpassed the present height, were submerged, and still the depression continued till the land sunk to at least 25 feet below its present level. At this level it appears for a while to have remained stationary, allowing time for the denudation of cliffs and the accumulation of beaches, one of which, now 25 feet above high-water mark, is to be seen at Anchor Head and Birnbeck Cove (Fig. 12), Weston-super-Mare. Finally a movement of elevation set in, as indicated by the raised position of the beach just mentioned, which ceased, however, after the land had risen 25 feet. Since then the country has apparently enjoyed a period of repose.

FIG. 12.

SKETCH BY MR. DAY OF RAISED BEACH IN BIRNBECK COVE, WESTON-SUPER-MARE. 1866. "Geol. Mag," Vol. iii, p. 115.



H. W. L. High Water Level.
25 feet. 25 feet above H. W. L.
a. Modern Beach.
b. Ancient Beach.
c. Ancient Sand dunes.
d. The "Head."
e. Ancient Cliff.
f. Carboniferous Limestone.

EXCURSION TO MAIDSTONE.

JULY 11TH, 1880.

Director:—PROF. J. MORRIS, M.A., F.G.S.

(*Report by* THE DIRECTOR.)

On arriving at Maidstone, the party, accompanied by Mr. Bensted and Mr. Adams, of Maidstone, and by the Curator, visited the Museum, and inspected the series of interesting fossils and antiquities, illustrative of the palæontology and archæology of the country, which give a special value to the Maidstone Museum. Many of the specimens had been collected by the late Mr. Bensted, F.G.S., an old Member and good friend of the Geologist's Association, from the immediate neighbourhood of the county town.

The Museum also contains a collection of Mammalian remains from the well-known Post-Pliocene Gravel pits of Aylesford, subsequently visited by the party. After having been liberally regaled with refreshments, the visitors left the Museum, and made their way to the " Iguanadon quarry," so-called from the circumstance of a considerable part of the remains of that reptile having been found here in 1834. These remains now form a prominent feature in the Mamtellian collection of fossils at the British Museum. The Director especially pointed out the fissures filled with sandy loam at this high level above the Medway, from which remains of *Elephas* and other vertebrate animals had formerly been obtained, and which had been described by him in the " Magazine of Natural History " for 1836, p. 593. Associated with these are three species of shells, which are also found in the Loess of the Rhine, viz., *Succinea oblonga*, *Pupa muscorum*, and *Helix plebeia*.

The Preston Hill quarries, about two miles to the north, were next visited. Here Prof. Morris, under adverse meteorological conditions, gave a general sketch of the stratigraphical position of the beds displayed. Some of the common fossils of this portion of the Lower Greensand were seen, and specimens obtained by members of the party. Leaving these fine quarries of the Kentish Rag, the Members proceeded to the Aylesford pits. An interesting explanation was given by the Director of the relation of these beds to the other Post-Pliocene deposits of the Maidstone Valley. The gravel consists of pebbles, derived from rocks which occur in the drainage area of the Medway, and although no shells have been

obtained, remains of the Elephant and Rhinoceros had been frequently found. Some specimens of these were seen in the quarry, and many are now deposited in the Museum. Although the weather was not all that could be desired, the party had been highly interested, and, after a repast at Aylesford, returned from that station to London.

EXCURSION TO LEITH HILL AND DORKING.

SATURDAY, JULY 24TH, 1880.

Directors:—REV. A. IRVING, B.A., B.Sc., F.G.S., and A. C. MAYBURY, D.Sc., M.R.C.S., F.G.S.

(*Report by* DR. MAYBURY).

The Members of the Association left Victoria Station, by the 1 p.m. train, for the last short excursion of the season, the object being to traverse the district from Ockley to Dorking. Prof. Rupert Jones, F R.S., President of the Association, a pleasing and valuable accession, joined the ranks at Dorking.

The Members of the Geologists' Association have often visited districts similar, stratigraphically and physically, to the one in question, so that the following memoranda must be taken as indicating the *chief* points which were brought out by the Directors. On leaving the train at Ockley—where Mr. H. Hawkings, F.G.S., of the Geological Survey, who has recently been engaged in mapping the superficial deposits of the district joined the party—the brickyards near the station were inspected. The Weald Clay, here exposed, had its usual characters—stiff, blue, and weathering red from the peroxidation of its iron. In it were intercalated Weald Sands, forming a local lenticular mass; they are very finely laminated, and are interstratified here and there with thin bands of clay. The existence of the clay beneath the Weald Sands was indicated by the occurrence of water at the base of the section. The strike of the rocks is here E. and W., and the dip is to the N., at an angle of 2° or 3°. In passing, from this the first pit, in an easterly direction, to the second, Weald Clay of older date was passed over, so that one stood here on the clay which underlies the sandstone in the first section. No fossils, with the exception of some carbonized wood, have been found here, though in the

brick fields at Holmwood Cyprides are abundant, thus proving the fresh water character of the deposit.

The line of march was then through the village of Ockley to Stone Street, were a turn was made to the north along the Causeway. After proceeding for some time on the low-lying, level, Weald Clay, the party gradually got on to higher ground and rocks of later date, viz., the Atherfield Clay (the lowest member of the marine Lower Greensand) and the Hythe Beds which immediately follow.

Having attained the summit of Leith Hill, from an elevation of some 970 feet, a magnificent view of the surrounding country rewarded the exertions of the geologists. The Hythe Beds of Leith Hill are composed of sands and sandstone, without any calcareous matter, with occasional intercalated siliceous bands. The prevailing colour is red, studded with green particles of glauconite. It is in the absence of calcareous matter that these beds differ from those of the same age in the Godalming area, where the Bargate-stone is most typically developed, consisting of a calcareous sandstone equivalent to the uppermost portion of the Hythe Beds.

On looking southward one sees an abrupt escarpment for about 200 feet, when the slope becomes more gradual, and extends far out into the Weald, so that we have formed, roughly speaking, a parabolic curve. The incoming of the clay is revealed by the occurrence of a line of springs, where the sandstone rests on the Atherfield Clay, and the appearance of fields and oaks indicates the same as the diminution in the slope of the ground.

Leith Hill and the surrounding district, interesting for many reasons, teach us some points in physical geology worthy of note. The area may be regarded as a plateau, sloping gradually to the north, which slope corresponds with the dip of the beds, viz., about 2° or 3°, and this inclination is well seen in a section due east from the Tower. It forms an extensive tract, corresponding in general characters with the Bagshot district, and clad with heather, furze, and fir trees. The ground has been sculptured by subaerial denudation, and valleys have been produced whose general direction is at right angles to the strike of the beds, *i.e.* to the axis of disturbance of the Wealden deposits. The valleys are probably in the direction of the original Secondary fissures, which were produced when elevation took place. Denudation has deepened these

fissures to different extents. In some cases (*a*) not cutting through the Hythe Beds, (*b*) in others exposing the Atherfield Clay, and (*c*) in yet others making the Weald Clay visible. Hence, in the first case, the valleys are dry, in the two latter cases wet or damp. In some instances the denudation has been stopped by a band of harder rock in the Hythe Beds, so that we have a small waterfall comparable with what obtains in the Isle of Wight, where a hard ferruginous band in the Lower Greensand resists the action of running water, and gives rise to the Chines.

On the homeward journey through Cold Harbour, Hythe Beds, Atherfield Clay and Weald Clay were passed over, for though travelling in the direction of the dip, and therefore getting on to rocks of later date, denudation had, in two or three cases, caused lower beds to crop up at the surface.

On nearing Dorking a line of fault, running east and west, was crossed. The *upthrow* is to the extent of 100 feet, and is on the south of the fissure, the Weald Clay (from which later deposits have been removed) being brought into juxtaposition with the Hythe Beds. Further evidence of this fault may be had in the fact that on the road to Guildford, beyond the Rookery, and near Wotton, sandstone is at a greater elevation than the Bargate-stone, though the latter is on a higher *geological* horizon. The occurrence of this fault has had much to do with the altitude of the Leith Hill area, and has an important bearing on the question of water supply, because that portion of the rain which percolates through the Hythe Beds of the area, in addition to leaking out at the junction of the sands and clays, will, probably, to a great extent be borne to a lower level through the fissure, so that in sinking a well between it and London there would be an absence of the water which fell as rain on Leith Hill.

After, at the White Horse Inn, bringing into play the "recuperative energies of the constitution," the Members took train from Dorking, having spent a very pleasant day under favourable conditions.

EXCURSION TO BRISTOL.

MONDAY, AUGUST 16th, AND FIVE FOLLOWING DAYS.

Directors :—PROF. W. J. SOLLAS, M.A., F.R.S.E., F.G.S., &c.; REV. H. H. WINWOOD, M.A., F.G.S.; G. F. WHIDBORNE, ESQ.; and A. C. PASS, ESQ.

(*Report by* PROF. SOLLAS.)

The Members of the Association left London by the 10·30 a.m. train, and on reaching Bristol at 3.30 p.m. were met by the Directors and S. H. Swayne, Esq., Secretary of the Bristol Museum. On assembling outside the station, they were informed of the programme for the day, and at once proceeded through the town to Brandon Hill, staying a few minutes on the way to observe the fine Norman gateway, near the Cathedral. At the foot of Brandon Hill, on the west side of Woodwell Lane (Jacob's Well), a large quarry, then being worked, afforded a good exposure of the Millstone Grit, and the Triassic conglomerate unconformably overlying it. The conglomerate was found to consist of fragments similar in lithological character to the grit below, affording an instructive instance of the general rule that the Triassic breccia corresponds in character to the rocks it covers, and from which—we may add as an inference—it has been derived. Crossing Woodwell Lane the Trias breccia was again seen, and the walk continued from the old river fort up the hill, along the ancient line of fortification to the summit, whence an extensive view was obtained of the surrounding country. On the north and east a thick growth of tall chimnies indicated the northern part of the coal-basin; on the south-west Ashton Hill, marked by a conspicuous clump of trees, prolonged the line of the Millstone Grit on which we stood; on the south, Dundry Hill, the remarkable outlier of Inferior Oolite was seen, and on the north to north-west, the buildings of Clifton scattered over Millstone Grit and Trias. From Brandon Hill the walk continued to the Museum (which was thrown open to the Association by the kindness of the Secretary), and here a short exposition was given by Prof. Sollas of the fossils and minerals which occur in the formations to be visited during the week: the fish remains from Portishead, Miller's collection of crinoids, the series of Carboniferous Corals, Agassiz's types of fishes, Austin's fossils from the Millstone Grit, the Hig-

gins' collection from Aust Cliff, and the faunæ of the Liassic Zones were particularly pointed out.

Mr. Tebbs called attention to a specimen of the jaws and teeth of a recent *Rhinobates*, as illustrating the nature of the dental apparatus of the ancient Rays.

The Members then proceeded to the Observatory Hill on Clifton Down, whence they looked down on the Avon gorge, bounded by the Clifton and Durdham Downs on the one side, on the other by the Leigh Woods, and spanned across by the adjacent suspension bridge. Away on the south stretched the Somersetshire part of the coal-field, the limestone of the Downs plunging out of sight conformably beneath it, to reappear as it rises on the south in the faintly visible range of the Mendips (16 miles to the south and over 1000 feet high). (See Fig. 11 in Prof. Sollas' paper "On the Geology of the Bristol District," p. 389.) Much nearer, about four or five miles south, Dundry Hill stood clearly out to view, an outlier of Inferior Oolite in nearly horizontal beds, standing on wide foundations of Lias and still more extensive Trias, under which the Coal Measures of the area are nearly altogether buried out of sight. With this hill before us, 500 feet higher than the high ground on which we stood, we were led to restore in fancy the wide-spreading sheets of Mesozoic deposits which had at one time continued the broken edges of the Dundry strata across the surrounding country and over the Downs far above our heads, to end in some unknown boundary on the west. Then dismissing from our minds the strata we had recalled for a moment into existence, and looking upon the paltry remnant preserved as Dundry Hill, we were able to gain some slight idea of the colossal magnitude of the mass which had been swept off the land and spread abroad over the bottom of the sea by subsequent denuding action.

The lowest beds of the Mesozoic are known, as was pointed out, to still extend over the Downs, and close to the place on which we stood we were able to examine a dyke of Trias, now standing like an artificial wall at the edge of the cliff, but originally an infilling of breccia in an open joint of Carboniferous Limestone at the bottom of the Triassic sea. Mr. Pass explained that the quarrymen had removed the limestone bounding the fissure, and had left the dyke itself behind on account of its greater hardness and impurity. Several other small infillings were observed, and one in particular, which had been cut through in making a new path to

the cliff; this was of considerable interest, since Rhætic fish-teeth had been extracted from it. Some of these teeth were exhibited to the Association by one of the toll-takers of the bridge, who had obtained them himself and mounted them by the side of similar ones from Aust, to show their specific identity.

We then descended by the Zig-Zag to the river side, and walking below the cliffs from the point below Windsor Terrace to the New Road, examined the coral beds, the great fault, and made out the section shown in Fig. 6, *loc. cit.*

East of the section the Coal Measures succeed the Millstone Grit, and are covered by New Red deposits.

Continuing along the New Road, the classic section of a Trias beach, figured by De la Beche, was reached and examined (Fig. 4, *loc. cit.*). The boulders, some of great size, all more or less rounded at the edges, were found to consist of Carboniferous Limestone and Mill-stone Grit, which are both *in situ* closely adjacent.

A good day's work ended by bringing us to the Imperial Hotel, where arrangements had been made for the accommodation of the Association during the week.

Tuesday.—Portishead and Clevedon. The Members left by the 9·10 a.m. train for Portishead, and on reaching there were joined by the Rev. B. Blenkiron, the first discoverer of fish remains in the Old Red Sandstone of Portishead. They at once visited the quarry near the station, where some time was spent in examining the Old Red Sandstone, Mr. Hinde finding a few imperfect fish remains. The Trias was seen resting upon it unconformably. Mr. Blenkiron then led the way to the old landing stage, where the section, figured by Sir Hy. de la Beche, showing Trias breccia resting on the edges of vertical Old Red Sandstone beds, was observed (Fig 5, *loc. cit.*).

We then walked through the wood to Portishead Point and Fort, and over the beach of Woodhill Bay, crossing numerous small anticlinal and synclinal folds of Old Red Sandstone, exposed in plan and section along the shore. We then turned inland, and visited the quarry overlooking the Bay, the Old Red was again seen here, and a solitary fish scale obtained from one of its beds ; continuing inland to the east, it was predicted, from the dip of the beds in the quarry, that we should soon reach the Carboniferous Limestone, and fragments of the Polyzoa beds were in accordance with the

prediction, found scattered over a field; this afforded a text for some remarks on the method of geological mapping. We then returned to the coast, and after picking up a few fragments of sandstone on the beach, containing *Holoptychius* scales, succeeded in discovering the fish-bed *in situ*, on the south side of Woodhill Bay. As we proceeded along the shore, the unconformity of the Triassic breccia on the Old Red Sandstone was displayed in perfection along the magnificent cliff section. At one point the Trias beach-deposit was seen abutting against, and, indeed, to a slight extent, underlying the old Carboniferous cliff, at the foot of which it had been formed; while, close by its side, a recent beach similarly disposed against a recent cliff, afforded a striking illustration of its method of formation, and bore speaking testimony to the doctrine of uniformity. The walk continued for a considerable distance beneath the cliffs, the unconformity continuing all the way, till tired of rough walking, and literally satiated with the section, we ascended the cliff and walked to Leedy by the path along its edge. At Leedy we halted for a while, and Prof. Sollas pointed out the line along which the old Post-Carboniferous plain of marine erosion sloped from the Mendips, over Bleadon, grazing the Steep Holme, and then the Flat Holme, till it ended a little below the sea level, beneath the Trias at Penarth, on the opposite coast, which could be just seen, thence to rise again into the coal-field of South Wales.

We then divided, and one division, after climbing up Walton Hill, was rewarded by a richly-diversified view over the beautiful valley to the east, and the channel on the west; the other division continued the walk to Clevedon, examining the interesting quarries of Dolomitic Grit, which occur on the left-hand side of the road. Galena and green carbonate of copper were obtained from the Dolomite; and the included pebbles of Carboniferous Limestones, known by the quarrymen as "Cockles," gave rise to a little discussion, some Members being at first scarcely prepared to admit that they were foreign inclusions. On the south of Clevedon the Carboniferous Limestone was reached, and the numerous fossils beautifully weathered out upon its surface afforded half an hour's play to the hammer.

Wednesday.—Aust Cliff. The 9 a.m. train was taken for New Passage, and under the able guidance of Mr. Pass the party made its way to the shore at Aust Cliff, where the section given in the Paper on the district, Fig. 10, was carefully made out.

By great good fortune several large blocks of the bone-bed were found on the beach, and these, on being broken by a heavy sledge, wielded by one of Mr. Pass's workmen, afforded the usual fish remains, which were got out by hammers of the more usual size. Mr. Hinde was successful in finding one of the most perfect specimens of a *Ceratodus* tooth which this locality has afforded. About one o'clock most of the party " on pleasure bent," deserted the cliffs for Tintern Abbey, but the rest, determined to " live a laborious day," continued their work on the bone-bed, and afterwards visited Patchway. At this cutting literally nothing could be seen, for since it was worked by Etheridge and others, it has become completely overgrown with that pest of geologists—a thick coating of turf—under which the rocks are now concealed from sight.

Thursday.—Weston-super-Mare, Uphill. Weston was reached at 9·35 a.m. by train, and drags, which had been provided by the Rev. H. Hastings, were in readiness to take us to Woodspring Abbey; arrived there, we spent a few minutes in looking over the ancient but well-preserved Tithe-barn, and then, under the guidance of the Rev. H. H. Winwood, walked to the end of the Swallow Cliff, where Mr. Winwood delivered an address on the geology of the district. Returning, we soon found the bed of amygdaloidal lava and volcanic ash with organic remains, conformably interbedded in the Carboniferous Limestone, which was found to dip at 40° to the south; immediately beneath the lava it showed signs of alteration, as if baked. The adjacent raised beach, consisting of well-rounded pebbles, with masses of shells filling up the interstices, was next examined. Its height above ordinary spring-tide high-water level is 25 feet.

The party now divided; some returned to the drags, a few others, including Dr. Foulerton, walked along the line of sand-dunes, which bound the head of the bay; observed further on a shelly beach, similar in character to that of Swallow Cliff, now in process of formation at the present sea level, and then waited at Birnbeck Cove for the rest of the party, who soon joined us. Here we were able to study, with complete success, the interesting section of a raised beach and sand-dune, covered by "Head," figured first by Mr. Day, in 1866. The section is given in the paper on the district, (Fig. 12.)

After lunching at Weston, we then drove to Uphill, and worked

over the cutting on the railway, of which sections are given in Figs. 8 and 9 *loc. cit.* The trap in the Carboniferous Limestone had been freshly exposed, and some very fine unweathered specimens were obtained. The Rhætic bone-bed was found displaying its usual characters, minus the bones. As there was no promise of obtaining fossils, we caught the first train from Uphill station and returned home.

Friday.—Cheddar, Wookey Hole and Wells. The Members left Bristol at 8.40 a.m. in a saloon carriage, which Mr. Pass had been successful in obtaining, and reached Cheddar at 10.24. Here they were joined by Mr. Parker. The Cheddar cave was first visited, and the one next door to it, which has not yet received a name. In this we found the cave-earth still remaining, and a short search brought to light numerous imbedded bones. We next were shown over Cox's Stalactite Cavern, which, for the beauty of its stalactites, is almost unrivalled in England. Then we proceeded up the gorge, observing on the way the identity in dip of the Limestone beds on each side of it; a measurement gave 20° on one side, and 22° on the other. Some amusement was caused by a clever speech from Mr. Parker, who controverted the usual views held by geologists with reference to the excavation of the gorge by water. The party, *more sua*, now divided, one group, led by Mr. Pass, the Director of the day's work, took train to Wells, the other, led by Mr. Parker and Prof. Sollas, walked over the Mendips through the village of Priddy, where they saw one of the springs which supplies the river Axe, flowing out into a concealed swallow-hole, and descended over the Lower Limestone Shales, down the ravine which lies west of the Ebber rocks, and in which the Old Red Sandstone lies faulted against the Carboniferous Limestone; (some returned to see the Ebber rocks), and all this party reached Wookey Hole just as the other division was coming out of it. The cave was well illuminated, so that, in addition to the evidence of deposition afforded by the stalagmite, the signs of erosion could be plainly traced in the water-worn aspect of the walls. Joint blocks which appeared to have quite freshly fallen were noticed on the floor, and so the recession of the roof might be said, without undue exaggeration to have been seen in progress. On emerging from the cave, attention was called to the ravine into which it opens. The connection of the two required no comment, a clearer instance of a ravine which is simply "a cavern unroofed to the light of

day," would be difficult to find. We examined the Trias conglomerate surrounding the mouth of the cave, and welcomed to the light the river Axe, which we had last seen, or at least a part of it, falling down the Swallow Hole of Priddy.

The Cathedral of Wells was wandered over till dinner time, when a substantial repast was spread before the Association at the Swan Hotel. Several toasts were drunk in the spirit of good fellowship, Dr. Foulerton expressing the feeling of the meeting in a speech of the happiest good humour, and the company returned home.

Saturday.—Radstock. On Saturday the Geologists' Association visited Radstock under the guidance of Mr. Whidborne. On arriving there about 11 a.m., they found a large basketful of fossils, which Mr. Sherring had obtained from the Timsbury Quarry, and placed at their disposal. They then started along the line (by permission of the Great Western Railway Company), to Huish Quarry, and after examining the section there, adjourned to the neighbouring colliery, where they obtained an interesting series of coal plants, including a fine *Lepidostrobus.* They then visited in order the Lias Quarries at Clandown, Bowldish, Mungar and West Tyning, finishing the day at the latter place, by examining another coal heap. Here the President, Prof. T. Rupert Jones, pointed out the difference in the aspect of the "Upper" and "Under" Clays, and drew attention to certain interesting glassy surfaces caused by air bubbles, which had risen from the decaying vegetation, but being unable to escape had ultimately been crushed down between the laminæ to a mere film that just prevented the opposite surfaces from amalgamating.

The various Lias quarries showed well the "poverty of sediment" in this locality during the time of its formation; even in proximate quarries different zones being totally absent, so that the Middle Lias lies on the Lower in a kind of "false unconformity."

Amongst the fossils found were *Rhynchonella oolitica*, an Inferior Oolite species, which has been identified by Mr. Davidson (Oct., 1878), from the Middle Lias in this place, and one or two other brachiopods of very unusual shapes; a few univalves, some bivalves, a coral from the White Lias, besides a large number of *Spiriferina Walcottii*, Ammonites and Pholadomyæ.

On the Geological and other Causes that Affect the Distribution of the British Flora.

By G. S. Boulger, F.L.S., F.G.S

(Read January 2nd, 1880.)

The origin of the present paper was as follows:—Rather more than two years ago I was listening to an eminent local geologist lecturing on the top of Leckhampton Hill, Cheltenham, to a meeting of the Cotteswold Club. "You see," said he, "that narrow band of Oolite Marl only ten feet thick: not only does it preserve its character as a rock and its peculiar fossil, the *Terebratula fimbria*, over a wide stretch of country, but there are certain plants which grow only on this band, and are found nowhere else on the Cotteswolds." At the close of his discourse I requested the lecturer to favour me with the names of the plants to which he referred. "Oh," said he, "I am sure I forget. Somebody told me it was so." I turned to that excellent local geologist and botanist Major Barnard, whose hospitable home on the Midford Sands is well-known to Glo'stershire naturalists. "There are no such plants," said he. "The plants that occur on one bed in the escarpment occur on all." And so I found it to be. This turned my attention to the relation between indigenous plants and geological formations, and I venture to lay my results before the Geologists' Association, as connected, in the words of our second Law, if not with Geology, with "its Allied Sciences," especially that of Physical Geography.

To preface my special remarks on our British Flora, by a rapid outline of the general conclusions arrived at as to geographical distribution, I have to review much work, extending, however, over a short time, for this branch of science dates only from the time of Humboldt, who invented isothermal lines and divided tropical mountain floras into zones of altitude. He was followed by Meyer, who unfortunately, however, went back to parallels of latitude, not allowing for the great polar and equatorial deflexions of the isotherms produced by oceans and continental masses. The British Isles come entirely within Meyer's Cooler Temperate Zone, *i.e.*, between the isotherms of 12·5°C and 5°C, a zone only represented by Patagonia and the Falkland Islands in the

Southern Hemisphere. This corresponds to the altitude zone of deciduous trees with inconspicuous blossoms, mixed with social conifers, together with grass, pastures, and extensive heaths.

In 1833, Schouw divided the world into 25 Botanical Regions, the three first of which are (1st) that of Mosses and Saxifrages, or the Arctic Alpine, in which trees are absent and the herbaceous plants have a dwarf mode of growth, with large and bright flowers; (2) that of the Umbelliferæ, or of North Europe and Asia, including the regions of conifers, deciduous trees, grasses, and cereal grains; and (3) the Mediterranean, or region of Labiatæ and Caryophyllaceæ, of evergreen trees and shrubs, of figs, olives and the vine. De Candolle's great work, "Géographic Botanique" (1855), to which I shall have to allude again, is a storehouse of facts as to the influence of physical conditions upon plants. Within the last few years, in his "Vegetation der Erde," Grisebach has given a new division into 24 regions, in which he sub-divides his Europœo-Siberian Forest region into seven zones—1, the French zone of the sweet chestnut; 2, the German zone of Pinus Picea: 3, the Hungarian zone of Quercus Cerris; 4, to which England belongs, the Russian zone of exogenous forests; 5, the northern zone of coniferæ, in which the Scotch Highlands fall.

In his various works on the geographical distribution of British plants, extending over nearly 50 years, Mr. Hewett Watson depends chiefly on heat for his groupings. Taking 1,425 as the number of well-marked British flowering plants, he makes six zones of heat, the Inferagrarian, in which 1,225 species occur, the Midagrarian 1,070, Superagrarian 760 species; and above the line of cultivation, *i.e.*, only on our mountain peaks, the Inferarctic 293, Midarctic 244, and Superarctic 111. He has also grouped the British flora under eight types of distribution, and, with his characteristic acumen, Edward Forbes arrived independently at almost identical conclusions, which his geological and theoretical knowledge enabled him to elucidate by the hypothesis of generic and specific centres, almost in the language of the modern evolutionist. Watson's types are—British, 532; English, 409; Intermediate, 37; Scottish, 81; Highland, 120; Germanic, 127; Atlantic, 70; Local or doubtful, 49.

In 1849, M. Thurmann published his "Essai de Phytostatique," in which he divides rocks into two classes, dysgéogènes, or bad soil-producers, and eugéogènes, or good soil-producers. The former

are such rocks as our Dolomite, Oolite and Chalk, highly permeable, and forming a dry shallow soil. The plants preferring such a soil he terms Xérophiles or Dry-lovers. It is noticeable that most dysgeogenous rocks are calcareous. Eugeogens, on the other hand, are less permeable, and, weathering more readily, form a deep moist soil. Plants preferring such soil are termed Hygrophiles, Damp-lovers. Eugeogenous rocks are of two kinds, coarse-grained and loosely aggregated, or light or fine-grained and closely aggregated or stiff; in a word, gravel and sand, or clay and loam. Each has its peculiar flora, sand-lovers and clay-lovers.

In his "Flora of Brazil," Martius termed the Xérophilous plants, Oreads or Sun-lovers; and the Hygrophilous, Dryads or Shade-lovers.

Insular climates are moister than those of continents. The climate of Ireland is more insular than that of England, and we find that Watson's Atlantic type occur mainly in the west, *i.e.*, are Hygrophilous; his Germanic type in the east, *i.e*,, are Dry-lovers.

The physical causes of distribution were admirably summarised in 1875, in the "Botanical Geography" of Mr. J. G. Baker, but as we shall see presently there is a serious defect in the merely physical views of which I have been speaking.

The sea moderates both heat and cold, and insular climates have thus what is termed a small hiberno-æstival variation. This is appreciable even on the two sides of England. The mean January temperature in the west is 40-43° F.; in the east, 37°; the mean July in the west, 63°-64°; in the east, 62°-63°; giving a difference of about 22° in the west end, of 26° in the east. Altitude and latitude are both obviously important, when we consider that a hill in Surrey, 1,000 feet high, will have the same temperature as the sea-coast in Northumberland; but the defect to which I have alluded is the omission of all genetic considerations, the question of the origin of forms. If we leave this out of view, a plant ought to exist wherever a suitable climate occurs, which is certainly not the case, and ought to be best adapted to the country in which it occurs, which also is not the case, as witness the Anacharis in our streams and the white clover in New Zealand. Distribution was first reviewed from an evolutionary stand-point by Mr. Bentham, in his address to the Linnæan

Society. He recognises three tolerably ancient floras, Northern, Southern, and Tropical; the first of which has long been divided into that of the Old and New World by the severance of America from Asia, and the upheaval of the Rocky Mountains. It is, however, preferably divided into three secondary floras, the Arctic-Alpine, common to both hemispheres, and with interesting Alpine outliers, relics of the Glacial Period, the Intermediate or Temperate flora, and the Mediterraneo-Caucasian, which extends to the Himalayas, Scinde and the Arabian and African deserts, with outliers even on the Cameroons. It forms six-sevenths of the flora of Europe.

The flora of the British Isles is mainly an extension of the Germanic area of the temperate flora. As the floras of oceanic islands are characterised by a large number of endemic or peculiar types, so the recent separation of the British Isles from the Continent will be recalled to the mind of the geologist by the fact that they contain no peculiar species. Since that separation differentiation, though it seems in some of the more variable genera to have proceeded some way, has not yet become of specific importance. We have only one non-European species, *Eriocaulon septangulare*, probably brought by migratory birds from America to West Ireland and the Hebrides.

But besides the Germanic element we have in our flora, especially in the south-west, traces of another, the Atlantic type of Watson and Forbes, probably of South African origin and of great antiquity. This is represented by the Gorse, Genista and Broom, the Arbutus, Mediterranean, and Cornish heaths and allied plants, the Lobelias, the Gladiolus and the Sibthorpia, "more nearly allied to corresponding Cape species than they are to each other." This outlier seems to be the result of migration along the highlands of East Africa from Natal to Abyssinia, hence to the Cameroons and *viâ* Morocco to West Europe.

We may then, I think, regard the causes of distribution as of two classes, genetic or original, and physical. Genetic causes seem to be rather instrumental in determining the prevailing Orders or genera of any flora than its species, which are the result of local or physical causes. These last are of two classes—(1) means of dispersal; (2) checks to dispersal or causes of survival; for though a seed may reach a new locale or even grow, it by no means follows that the species will become permanent.

The chief means of dispersal are birds (*e.g.*, the Nutmegs in the Moluccas), in order to attract whom plants develop luscious or brilliant fruits or seeds; the wind, for conveyance by which agency they have winged fruits and seeds, as in the Compositæ; ocean currents, rivers, man, and hairy or woolly quadrupeds. Allowing for differences of level and soil we generally find the same plants throughout the valley of a river, and shore plants extend along the banks of a tidal estuary. The scene of the Exhibition of 1862 was for some years covered with exotic plants, and the ballast-heaps of the Gloucester ship canal, the neighbourhood of the cloth factories at Stroud, where Australian wool is used, and our corn-fields sown with foreign grain, are fertile sources of introduction.

More important, I think, however, are the checks to dispersal or causes of survival within a limited area. Few plants are so elastic as to disregard all of these. I reckon five classes of these.

First, barriers, such as wide ocean-basins (and here I would notice that we have probably a different law from that of animals, width being of more importance than depth), deserts, and mountain-chains.

Second, climate, which, from our point of view, consists chiefly in temperature and humidity depending on latitude, altitude, and proximity to the ocean combined. Its importance can hardly be over-estimated. We read its effects in every outline of stem and leaf as surely as we read the nature of the fertilizing agent, whether wind, fly, bee, moth or humming-bird in the structure of the flower and the pollen.

Different plants require different degrees of temperature for their germination and for their growth. Annual plants require all their heat during a short space of time, and consequently diminish in number as we travel towards the poles. They may be termed heat-lovers or Philotherms. They are also generally Oreads or Sun-lovers, Xérophiles or Dry-lovers, growing in shallow soil, and are more abundant and extend farther towards the pole in the dry continental areas than in islands. Trees and shrubs, on the other hand, take their heat gradually and grow only by fits and starts, using then their stored up energy. Their main danger is from sudden fits of cold during the growing season. They are, therefore, termed cold-fearers or Frigo-fuges. This is especially the character of evergreens. They are Dryads and Hygrophiles,

requiring moist deep soil, loving shade and extending pole-wards in insular climates.

With regard to moisture, plants are either Xérophilous (Dry-lovers), Hygrophilous (Damp-lovers) or Noterophilous, of Intermediate or Indifferent constitution. Xérophilous plants belonging to the great division of flowering-plants, the Dicotyledons have often thick, fleshy leaves, with leathery rind and pulpy interior, as in the Houseleek and Stonecrops; or they are wiry shrubs with small, hard, rigid leaves, as in the heaths; whilst among Monocotyledons, they produce bulbs, as in the Hyacinth, Daffodil, and Colchicum. Prickles and hair are also closely connected with a dry climate.

Hygrophilous plants form large trees, covered with green leaves or erect-growing herbs or climbing shrubs.

The third check to dispersal is difference of soil. Though to some extent, the chief subject of my paper, it is after all but of secondary importance. The occurrence or non-occurrence of a species on a particular soil depends chiefly on the texture of the soil, *i.e.*, its permeability or drainage. Most plants at least are indifferent as to whether they grow in a quicksand or a wet loam. Many plants common on our Chalk downs will grow equally well in dry sand or in the calcareous clays of the Upper Lias.

The second point about a soil is its chemical composition, and though I doubt if plants care to discriminate between silica and alumina, there is, I think, no doubt that several require lime. Of course our Chalk produces a slightly different soil from the Oolites, the Mountain Limestone, or the Dolomite; but I know no species confined to one geological formation, and believe that (apart from texture and composition) the age of a rock has no influence on its flora.

The fourth cause of limitation are Watersheds. Seeds and roots being carried down by streams are spread over the river-basin, but need not extend beyond it. Fifth and last: the struggle with existing forms.

From the consideration of this diversity of natural conditions, it may be easily surmised that any attempt to divide a country into botanical districts must be artificial; but the most artificial method that could well be adopted is that we have hitherto been content with—viz., that into counties. Isotherms would be more rational, but they are neither obvious in the field nor can they be enclosed,

owing to differences of level. Local cappings of Post-Pliocene formations, outliers and contortions are objections to a purely geological mapping for botanical purposes; so we have fallen back on watersheds as obvious and convenient, and, to a considerable extent, natural boundary-lines, and I am not without hope that the critical study of varieties may show this method as useful in a small as on a large scale. Still we have here some difficulties, the chief of which are, I think, low-lying watersheds, as in the Weald, and limestone plateaux with underground drainage, as in the Cotteswolds. We have naturally an East and a West Flora, a North and a South one, a Coast and an Inland one. Our West and North Floras are mainly mountain floras and mainly Palæozoic, whilst to the Continental climate of South-East England is to be added the fact that much of its surface is chalk (dysgeogenous), therefore Xérophiles predominate.

If we analyse the British Flora, we find that of some 1,600 forms, whilst, perhaps, 100 are so universal as to tell us little or nothing; another 150 are difficult of recognition, and have probably been often overlooked, so that we do not know their distribution; about 40 occur only in one or two spots, and are, therefore, untrustworthy; 120 are not truly native; 20 belong rather to France, being found only in the Channel Islands; 50 are peculiar to Scotland and 16 to Ireland. These lists are instructive.

SCOTCH (59).

Caltha radicans.		
Draba inflata ...	...	Alpine.
D. rupestris ...	...	Alpine.
Viola arenaria.		
Polygala austriaca ...	...	Stuned, rosulate.
Cerastium trigynum ...	Caryophyllaceæ.	Alp. perennial.
Areneria noloagica ...		Alp. per. stunted.
Cherleria sedoides ...		Alp. per. stunted.
Alsine uliginosa ...		Alp. per. stunted.
Sagina saxatilis ...		Alp. per. stunted.
„ nivalis ...		Alp. per. stunted.
Oxytropis Halleri ...	...	Xerophilous.
„ campestris ...	...	Alpine.
Astragalus alpinus ...	...	Alp. perennial.
Sibbaldia procumbens...	...	Alp. perennial.
Epilobium alpinum ...	...	Alp. perenn. rosulate.
Linnæa borealis ...	...	Perennial.

Gnaphalium norvegicum	...	Alp. perennial.
„ supinum ...	...	„ „ tufted.
Mulgedium alpinum ...	...	Alp. perennial.
Hieracium dubium ...	...	Perenn. Xeroph. Rupestral.
H. obtusifolium, &c.	...	
H. flocculosum ...	...	
Arctostaphylos alpina...	Ericaceæ.	Alp. perenn. stunted.
Loiseleuria procumbens		„ „ „
Menziesia cærulea ...		„ „ „
Pyrola uniflora ...		Perennial.
Gentiana nivalis ...	...	Annual, Alpine.
Veronica alpina ...	...	Alp. perennial.
„ saxatilis ...	...	Alp. perennial.
Ajuga pyramidalis		
Myosotis alpestris ...	...	Alp. perenn. stunted.
Pinguicula alpina ...	...	„ „ „
Primula scotica ...	...	„ „ „
Betula nana ...	...	„ „ „
Salix lanata ...	...	„ „ „ shrubs only
„ Arbuscula ...	...	„ „ „
„ Myrsinites ...	...	„ „ „
„ reticulata ...	...	„ „ „
Potamogeton lanceolatus		
„ nitens		
Goodyera repens		
Corallorhiza innata		
Luzula arcuata ...	...	Dwarf. Alp. perennial.
Juncus trifidus ...	...	Alp. stunted perennial.
„ castaneus ...	...	Alpine. „
„ biglumis ...	...	„
„ balticus ...	...	Sand-loving „
Eriophorum alpinum ...	...	Perenn. Alp. tufted.
Carex rupestris ...	...	
„ lagopina ...	...	„ „
„ alpina ...	...	„ „
„ aquatilis ...	...	„
„ rariflora ...	...	„ „
„ vaginata ...	...	„ „
Hierochloa borealis ...	...	
Alopecurus alpinus ...	...	Alp. perennial.
Aira alpina ...	...	Alp. perenn. stunted.
Poa laxa ...	...	Alp. perennial.

IRELAND (19).

Barbarea arcuata.		
Polygala grandiflora.		
Arenaria ciliata ...	...	Arctic (Sligo).

Saxifraga Geum ...	...	Spain and Portugal.
„ hirsuta ...	...	„
„ umbrosa ...	...	„
„ Sternbergii	...	
Arbutus Unedo ...	Ericaceæ.	Spain, S. France.
Menziesia polifolia ...		W. France, Spain.
Erica hibernica ...		„ „
Pinguicula grandiflora		
Potamogeton sparganiifolius	...	
„ Lonchitis	...	
„ longifolius	...	
Naias flexilis.		
Neotinea intacta ...	...	N. Africa.
Spiranthes gemmipera	...	N. America.
Sisyrinchium Bermudiana		„
Carex Buxbaumii		

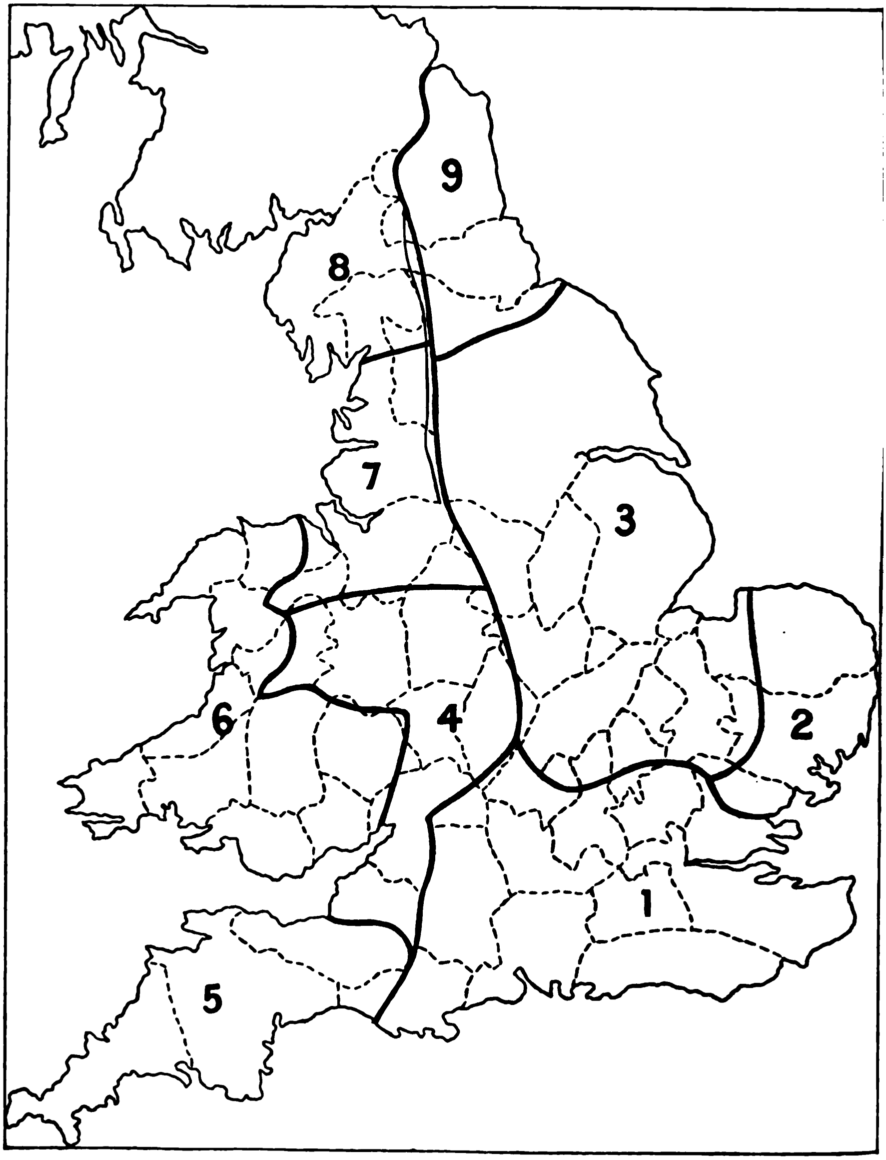
CHANNEL (18).

Ranunculus-ophioglossifolius.	Orobanche arenaria.
„ chærophyllus.	Echium plantagineum.
Sinapis incana.	Armeria plantaginea.
Brassica cheiranthus.	Orchis laxiflora. E. Europe.
Helianthemum guttatum.	Allium triquetrum.
Silene quinquevulnera.	Scirpus pungens.
Ononis reclinata.	Lagurus ovatus.
Centaurea aspera.	Cynosurus echinatus.
Gnaphalium luteo-album.	Bromus maximus.

I venture to propose a division of England into nine Botanical Provinces, viz.:—1. The Thames and South-east westward to the axial watershed and that between the Axe and Otter—a province entirely Neozoic. 2. East Anglia, the valleys of the Blackwater, Stour and Yare. 3. East Fen and Secondary, the Valleys of the Wash and Humber. 4. The Vale of Severn, including that of the British Avon, but not the more mountainous one of the Wye. 5. The Peninsula of Devon and Cornwall. 6. The Welsh Mountains, including the Wye valley, but not that of the Dee. 7. The Lowlands of Cheshire and Lancashire. 8. The Lake Mountains with the valley of the Kent. 9. Northumberland and the valley of the Tees. [See accompanying Sketch Map.]

In conclusion I would call your attention to a few species characteristic of certain soils, classing them as Xérophiles,

MAP SHOWING BOTANICAL PROVINCES OF ENGLAND.



Calcophiles, Hygrophiles, Pelophiles, Psammophiles, and Nemophiles.

DRY LOVERS (XEROPHILES)—
Daphne Laureola.
Orchis pyramidalis.
Fagus sylvatica.
Rosa rubiginosa.
Gymnadenia conopsea.
Ophrys apifera.
O. muscifera.
Herminium monorchis.
Carduus acaulis.
Thalictrum minus.
Campanula rotundifolia. (?)
Draba verna.

SAND LOVERS (PSAMMOPHILES)—
Cytisus scoparins.
Saxifraga granulata.
Digitalis purpurea.
Betula alba.

CLAY LOVERS (PELOPHILES)—
Lysimachia nemorum.
Alisma Plantago.
Alnus glutinosa.

LIME LOVERS (CALCOPHILES)—
Reseda.
Onobrychis.
Specularia hybrida.
Chlora perfoliata,
Neottia Nidus-Avis.
Aquilegia. (?)
Lychnis vespertina. (?)
Campanula Trachelium. (?)
Polygala calcarea.
Hutchinsia.
Anemone Pulsatilla.
Clematis (?)

DAMP LOVERS (HYGROPHILES)—
Caltha.
Cardamine pratensis.
Lychnis Flox-cuculi.
} on alluvium.
Geum rivale.

SHADE LOVERS (NEMOPHILES or DRYADS, Baker, p. 78)—
Lychnis diurna.
Oxalis Acetosella.
Asperula odorata.

ON THE CLASSIFICATION OF ROCKS.

BY THE REV. J. F. BLAKE, M.A., F.G.S.

(*Read March 5th,* 1880.)

Of the three great groups of rocks, as ordinarily distinguished—the Aqueous, Igneous, and Metamorphic—the first has never given rise, nor is perhaps ever likely to give rise, to any considerable discussion, except as regards the age, which has far more interest to Geologists than the peculiarities of structure. The particular relations of the crystalline rocks to each other and their consequent grouping was for a long time the subject of exciting controversy, which, lulled to sleep for a time, seems reviving once more in a modified form. The flood of light which has been poured on the subject by the microscopical examination of thin slices has rendered several petrologists averse to the old classification by which

the Igneous rocks were divided into Volcanic, Trappæan, and Plutonic, as appearing to be inconsistent with more newly discovered facts, and several fresh arrangements have been recently proposed. The classification of such rocks may, therefore, be considered as at present *sub judice;* and on this account, without pretending to bring any fresh facts to the discussion, the present remarks are offered in the hope of showing how the newer facts may be arranged in their logical places, and the proposed schemes be, as far as possible, reconciled to each other, and to the older and time-honoured one. As there is always a tendency to the belief that the newest arrangement must necessarily be the best, it may be well to observe that the closer study of the structure of rocks, which is so marked a characteristic of our present Geological work, is but a revival, with improved means, of the mineralogy which played so conspicuous a part in rock-discrimination in the earlier days of the science; and yet the behaviour of rocks in the field was finally adopted as the basis of classification, and produced our present sub-divisions. The latter method was found to be most useful to the Geologist, and I doubt whether increased knowledge of the minute structure of rocks will do more than improve it.

In most of the newer classifications, which I propose to discuss, no notice is taken of the Geological relations of the rocks, but everything is based on what may be learnt from hand specimens or microscopic slides.

I will, in the first place, limit myself to the Igneous rock, and place side by side the older classifications, and those which have been more recently proposed.

As a representative of the former, I will take that given in the last edition of Jukes' "Manual of Geology," edited by Prof. Geikie, and dated 1872, as one of the best known and most authoritative.

PROF. JUKE'S CLASSIFICATION.

	Felspathic.		*Augitic.*
	Trachyte.		Dolerite.
	Pearlstone.		Anamesite.
	Andesite.		Basalt.
A. Volcanic	Phonolite.	Trachy-dolerites.	Wacke.
	Obsidian.		
	Pumice.		
	Trachyte tuffs, &c.		Doleritic tuffs, &c.

	Felspathic.	*Hornblendic & Pyroxenic, Felspar & Hornblende, &c.*
B. Trappæan.	Felstone.	Diorite.
	Pitchstone.	Diallage Rock.
	Clinkstone.	Hypersthene Rock.
	Minette.	Melaphyre.
	Kersanton.	Diabase.
	Kersantite.	Aphanite.
	Porphyrite.	Wacke.
	Felstone tuff, &c.	Greenstone tuff, &c.
C. Granitic.	Granite.	Syenite & its varieties.
	Syenitic Granite.	
	Pegmatite.	
	Protogine.	
	Graphic Granite.	

The great feature of this grouping is the prominence given to the middle group, of which the author says that it is a term of convenience only to indicate some rocks that have been formed by volcanic action, some that are more essentially granitic with many intermediate or undetermined rocks between the two.

Prof. Dana's classification, which proceeds on a totally different basis, being a chemical or mineralogical one, was published in the "American Journal of Science," in 1878, and the author's summary was transferred to the pages of the "Geological Magazine" for May, 1879.

PROF. DANA'S CLASSIFICATION.

I. Mica and Potash-Felspar Series.	Granite, Granulite, Gneiss, Protogine, Mica-schist, &c. Felsite, Trachyte and Leucite rock.
II. Mica and Soda-lime-Felspar Series.	Kersantite and Kinsigite, and the Nephelitic kinds of Miascite, Detroite, Phonolite, &c.
III. Hornblende Potash-Felspar Series.	Syenite, quartz Syenite, Syenitic-gneiss, Hornblende-schist, Amphibolite, Unakite, &c., Zercon-Syenite, Foyaite.
IV. Hornblende and Soda-lime-Felspar Series.	Diorite, Propylite, Andesite, Labradorite rocks, Saussarite Rock, Euphotide.
V. Pyroxene and Potash-Felspar Series.	Amphigenite.
VI. Pyroxene and Soda-lime-Felspar Series.	Augite-Andesite, Norite (Hypersthenite and Gabbro part) Hypersthenite, Dolerite (comprising Basalt and Diabase) Nephelinite.
VII. Pyroxene, Garnet, Epidote, and Chrysolyte rock, with little or no Felspar.	Pryoxenite, Lherzolite, Garnetite, Eclogite, Epidosite, Chrysolite, Dunite.

VIII. Hydrous Magnesian and Aluminous rocks with little or no Felspar.	Chlorite-Schist, Talcose-Schist, Serpentine, Ophiolyte, Prophyllite-Schist, &c.

In this not only the Igneous rocks, but those generally called Metamorphic are included.

The later edition of Jukes' "School Manual of Geology," edited by Jukes Browne, in 1876, contains a classification by Prof. Bonney, which is stated to be that to be used in a "Handbook of Petrology," promised by the latter, but which has not yet seen the light. This is somewhat on the same lines as that of Prof. Dana, but chemical composition gives way largely to structure.

PROF. BONNEY'S CLASSIFICATION.

	Matrix wholly crystalline.	Matrix semi-crystalline.	Matrix grassy.
I. Orthoclase Felspar.			
a, Quartziferous.	Granite.	Quartz Felsite.	Quartz-Trachyte.
b, Quartzless.	Syenite.	Orthoclase-felsite, Minette.	Sanidine-Trachyte. Pitchstone. Obsidian.
II. Plagioclase Felspar.			
a, Oligoclase, sometimes with quartz.	Diorite.	Porphyrite.	Andesite.
b, Labradorite or an allied mineral—no quartz.	Gabbro. Diabase. Dolerite. Basalt.	Some basalts ?	Tachylite.

The last classification which I shall cite is that of Mr. Rutley, in his golden book, entitled "The Study of Rocks;" a book which ought to be in every student's hands. The author states that the rocks named are considered as type-rocks of the respective groups.

MR. RUTLEY'S CLASSIFICATION.

I. Vitreous. Obsidian, Pumice, Perlite, Pitchstone, Tachylite.

II. Crystalline.

A. Typical groups. Granite, Felstone, Syenite, Trachyte, Phonolite, Andesite, Porphyrite, Diorite, Diabase, Gabbro, Basalt.

B. Rocks of exceptional mineral composition.

III. Volcanic ejectmenta.

IV. Altered eruptive rocks.

On the perusal of the descriptions of these several groups, it appears that they are made to include rocks which are often separated from each other ; thus, under Granite, we have also Porphyritic Granite, Felstone, Granitite, Cordierite-granite, Luxullianite, Haplite, Granulite, Greisen, Gneiss and Cornubianite; while Syenite includes also Minette, Kersanton and Kersantite.

These several classifications I now propose to discuss *seriatim*, after first laying down some principles which we ought to follow if classification is to be of any use.

The points in which Igneous rocks differ from each other are— 1. Their mineral composition. 2. Their structure. 3. Their origin. 4. Their age. The age of a rock ought in no way to enter into a descriptive classification, still less into the name ; for then we might have to invent a new name for the same rock in each epoch, and should lose the power of stating the facts about the age of such rocks. Thus, if, as Prof. Geikie says, some "petrographers retain the name Melaphyre as a geological term for all Doleritic rocks of Palæozoic age," the two names simply become synonymous, and we lose the power of stating that "most Doleritic rocks of Palæozoic age are melaphyres." So of the term Propylite for Tertiary Andesites, and Felstones for ancient Rhyolites, unless these terms contain some mineralogical meaning, they are simply tautologous. In like manner to call a group of volcanic rocks traps, simply because they were erupted in ancient times, reduces the important generalization that ancient volcanic rocks are very like modern ones into the apparently self-condemning statement that trap rocks are very like volcanic ones.

The mode of occurrence, that is, whether it has flowed as a lava or has consolidated beneath the surface, cannot in itself be allowed to influence the *name* of a rock if it otherwise remains constant in character; otherwise, if we were discussing whether some rock found intrusive beneath great piles of strata reached the surface elsewhere, we should have to ask whether *A* was elsewhere *B*. Whether we may profitably use the mode of occurrence for making the larger groups, opens up the great question between the recent and the earlier classifications. The great objection to its use is, that it makes the grouping a theoretical rather than a positive one. Certainly, when the structure and composition is ascertained, there is no difficulty in classifying the rock in the latter method—yet it tells us nothing we did not know before—and, in

point of fact, the better founded the theory, the better is it suited to be made the basis of classification, and hence it is a retrograde step to throw a theory over without replacing it. Often, indeed, a geologist is chiefly interested in the origin of the rock, and only cares to know its composition so far as it may throw light upon that—hence, whatever mineralogists, or cabinet petrographers may do, he will always require a classification which involves the origin.

With regard to the structure of rocks—as it appears to be proved that it depends on the rate of cooling, it is an important element in their discrimination—but being certainly less essential than their composition, should be subordinated to the latter. Thus, for the naming of rocks the great guide must be their mineral ingredients. The chief difficulty to contend with here is, that rocks will pass into each other, and there is always a temptation to enlarge the definitions accordingly; but, as Mr. Rutley remarks, "sharp, or moderately sharp definitions constitute the basis of all classification, and if these be abandoned, the petrological nomenclature becomes almost worthless."

First, now to examine Prof. Jukes' and Geikie's classification. We here find "Granitic" used as a group-name parallel to "Volcanic." This is substituted for "Plutonic," on the ground that it is "advisable to avoid terms that involve foregone conclusions." The term, however, either means that they occur in such circumstances as lead us to conclude, rightly or wrongly, their subterranean origin, which is all we mean by Plutonic, or else it is the same as Prof. Bonney's "matrix wholly crystalline," in which case structure is mixed up with origin in the classification. Since, moreover, there is so much discussion on the origin of granite, it seems unadvisable to use it as a group-name. Next we have the use of the word "Trappæan." This is made to include all Igneous rocks not formed in the neighbourhood of modern volcanoes, and excluded from granitic without any particular reason being given. With this wide range, the group seems to me, as it has seemed to many, an absurd one; a lava which flowed in ancient times appears to have just as much right to the name "Volcanic" as a recent one; and the use of the term "Trap," for a contemporaneous lava is certain to be rejected with the growing proof of the general identity of all lavas. It appears to me, however, that we require a name for those igneous rocks which are intrusive in long sheets

and dykes. Certain peculiarities appear to be involved in this mode of occurrence as in Pitchstone and Felstone, but these peculiarities are capable also of production in rocks which have flowed as lavas by a long process of devitrification. It is therefore improbable that any rock is exclusively a Trap rock, and the whole series may be represented also as belonging to the altered Volcanic rocks, or, in some cases, to the Plutonic. Nevertheless, the name is a useful one in the sense defined, and may therefore be retained.

With regard to the several rocks grouped under the three heads among the Volcanic—*Pearlstone* or Perlite, has reference to a structure induced in the rock after its formation, and therefore the name should not be placed in a parallel line with *Trachyte* and *Andesite*, which differ in their mineralogical ingredients, and the same remark applies to *Pumice*. Among the augitic rocks, *Anamesite* appears to be a useless name, as it is simply an intermediate term between *Dolerite* and *Basalt*; which latter will well cover it, as it commonly does for field geologists. Next as to the Trappæan: At present, *Minette*, *Kersanton* and *Kersantite*, appear to belong exclusively to this group, and to be the forms which *Syenite* and *Diorite* assume when found in dykes. The name *Porphyrite* seems to me a very objectionable one. It is slightly altered from porphyry, but really means the same thing, except its restriction to rocks which would otherwise be called *Andesites*, from their being essentially composed of a plagioclase felspar and hornblende, or augite. *Diorite* is essentially a plutonic rock, occurring often as a trap. With regard to such names as *Diallage Rock* and *Hypersthene Rock*, in which one mineral alone is abundant, it is scarcely logical to put these alone on a level with *Diorite*, &c., and to omit all reference to those in which some other mineral is predominant, as *Nephelinite*, *Leucitophyr*, or *Garnet rock*. As to *Melaphyr*, the term has been used in reality simply for Basalts or Dolerites of Palæozoic age. Mr. Rutley describes it under the former head, and states that it differs from ordinary basalt in containing decomposition products of compounds of iron. It is, therefore, an altered basalt, and the name should only be used when such alteration can be proved, and to indicate that it *has* been proved for the particular rock in question. *Diabase* is a name well fitted to raise all the difficulties that are possible in the nomenclature of rocks, and there is no more curious page in Mr. Rutley's valuable book than that on which this rock is described.

Compare his description of *Diabase* with that of *Dolerite* :—" Diabase may be regarded typically as a crystalline-granular admixture of triclinic felspar and augite, usually with more or less magnetite and titaniferous iron." "Dolerite . . . . contains augite, magnitite and titaniferous iron, but it has, in addition, other mineral constituents . . . . of these the felspars claim the most prominent place—they are triclinic." Thus they are both described in identical terms, but the order of enumeration is reversed. The real difference is that Diabase contains chlorite, and this is an alteration product; the rock is, therefore, an altered dolerite, as Mr. Allport has shown. It seems to be sufficient for some petrologists to prove that one rock is an altered form of a second, to justify the discontinuance of the separate names; but I cannot help thinking it a convenience to have a name to indicate the particular kind of alteration that has taken place. The additional mineral in *Melaphyr* and *Diabase* being, however, both varieties of chlorite, the first name may well be dispensed with. *Aphanite* is essentially a useless term, and nothing need be said of it—or of " *Wacke*." Among the granitic rocks, only two are really mentioned, for *Pegmatite* and *Graphic Granite* are only varieties, and *Protogine* is a metamorphic gneiss.

We now come to Prof. Dana's classification which has an entirely different basis and which may be much more debatable. He lays down as his principle that " the chemical and mineralogical composition of the *chief* constituents should be first considered and not crystalline form." In the latter part of the sentence he is striking at the use of the term plagioclase as a general term for felspar of a certain kind in rocks. The actual term plagioclase, as Prof. Bonney admits in his strictures on Dana's classification, is rendered rather of doubtful value since the discovery of microcline—a plagioclastic potash felspar, but it is usually meant as an abbreviation for " soda-lime-felspar," to which it has doubtless ceased to be synonymous. Passing this Prof. Dana lays down that the *names* should indicate no more than mineralogical composition, and not be used to separate rocks which differ only in structure. This strikes at the base of Prof. Bonney's scheme, which goes very largely upon structure, and yet so far as structure indicates origin or circumstances of formation we must agree rather with the latter, otherwise we could not separate shale from clay or grit from sandstone. These differences in texture, however, Prof. Dana allows may be indicated

as varieties, and this is perhaps enough. He argues especially against the use of the word *Porphyritic* to indicate any more than a particular condition of a rock. He makes a great difference between hornblendic and augitic rocks, in spite of the great chemical similarity of the minerals, because they may indicate geological differences of origin; it is of course on the very same principle that Prof. Bonney lays stress on structure. He regards mica and hornblende as too distinct in composition to be considered as replacing each other, and hence objects to such terms as Mica-diorite for a rock without hornblende or Hornblendic granite if no mica is present. These principles are most admirable as referring to specific rocks and deserve adoption, but his classification into groups rests in no way upon them. Surely one must conclude that accessory minerals have been confounded with essential and even composition taken no note of, while geological considerations are thrown utterly to the winds when such rocks as Granite, Gneiss, Mica-schist and Trachyte are all classed together, and one is led to ask what use such a classification can be to any one? Prof. Bonney's remarks on this are very good; he especially objects to group VII, on account of the diversity of the rocks included; this is indeed a "carpet bag" group, necessary on the method adopted, but yet unphilosophical, or a confession of our ignorance. On the whole it appears to me an artificial classification which can never assist a student seeking for a natural one.

Prof. Bonney's classification is an incomplete one, otherwise he would have to make a third sub-division of those which contain no felspar, and in this, as in Prof. Dana's group VII, "mineralogy and chemistry would have to be fairly thrown to the winds." There is no wonder that the author of this classification should dispute, *totâ vi*, Prof. Dana's objections to Plagioclase and Orthoclase when they take away the ground from beneath his feet; but however the former word may be limited, it still remains to show any just cause why the varieties of felspar should be made of so much importance. No doubt common Orthoclase is nearly confined to the more crystalline Plutonic rocks, but in the form of sanidine it occurs in many volcanic rocks as in Trachyte and Phonolite. Again even in Granite Orthoclase is very often associated with Oligoclase as in that of Leinster, and therefore the two sub-divisions can only mean "orthoclase present, orthoclase absent." That the presence of Orthoclase is of so great importance remains, I think, to be proved.

When we consider that Albite, a soda-felspar, is more highly silicated than Orthoclase and that Microcline, a potash-felspar, is triclinic, it is plain that the chemical composition is not indicated by the distinction of the felspars.

The importance of the character of the matrix is brought very prominently forward by this classification, and there can be no doubt that it is worthy of more consideration than has been given to it, though it may be doubtful whether it should occupy the second place; one point is brought out by it, which is of great interest, that is the approximation of Dolerite to the Plutonic rocks, especially to Gabbro. When it is remembered that Prof. Judd has shown that Granite may form the actual core of an extinct volcano, and Dolerite, from its crystalline character, must have consolidated under pressure, the association of the latter with the basic representative of the former cannot be very remote. Thus Dolerite may be a connecting link between the two great classes.

Mr. Rutley's grouping is, perhaps, scarcely intended for a classification, but merely for convenience of reference, otherwise one would observe that where the matrix is glassy with sporadic crystals, we have a rock more allied to a vitreous one than to a wholly crystalline one. It is remarkable that the typical groups contain the two *Porphyrite* and *Diabase,* though the author distinctly recognises all that can be said against the use of those terms. The group called "rocks of exceptional mineral constitution" is an equivalent of Dana's non-felspathic group, and the same arguments may be used against it. When rocks of this character are classed together the group becomes a mere catalogue, and it would have been far more useful if it had been shown what are the nearest allies of each. The establishment of a group under the title "altered eruptive rocks" is an admirable step, as Prof. Bonney remarks, there are probably as many altered igneous as aqueous rocks, only they are altered in a different way, the former by hydro-metamorphism, the latter by pyro-metamorphism. The only important rock, however, found in this group is *Serpentine,* and it would be still better to include in it all rocks derived by change from others, but in my opinion best to place each in connection with its unaltered representative.

These classifications belong to three great types, founded re-

spectively on the composition, the structure, and the mode of occurrence of rocks. Each embodies important elements in the history of rocks. Believing as we do that there is a cycle in the formation of rocks, that a sedimentary rock may be altered into a metamorphic, then into a plutonic, which under certain circumstances may be erupted as a volcanic rock, the chemical classification may be of use as keeping together what may be the successive forms of one and the same collection of materials. The objection obviously is that we can have no proof of the mass remaining unmixed during its changes. The classification by structure combines into groups those that have consolidated under similar conditions, but leaves out how those conditions were brought about. The third method is essentially a geological one, and however the two former classifications may commend themselves to chemists and microscopists, geologists proper will seek one founded upon this method, however much it may be modified by a consideration of the others.

One great feature in the natural history of rocks has as yet been only partially used in classification, and that is the change which rocks have undergone subsequent to their formation. In the case of sedimentary rocks which have become crystalline, this has been recognised in calling them metamorphic, but in the case of igneous rocks which have become devitrified, or otherwise changed by the long continued action of water, no special designation has been employed. One great improvement, therefore, would be the placing in parallel lines the original rocks and the altered form; thereby suggesting the question for any rock containing alteration products—what was its original form? Each rock-name might then stand for a definite mineralogical mixture of particular structure, and any introduction of a new mineral, or alteration in structure brought about subsequently, might be indicated by a definite name in the lists of altered rocks, while original differences of structure or the presence of important accessory minerals would give rise to a varietal name.

In the great groups no hard and fast line can be drawn, at all events in the geological method of classification, for a Plutonic rock may lie at the base of a volcano, and Trappæan rocks may reach the surface and thus become eruptive. So again with the Acid and Basic groups—there must always be rocks of inter-

mediate character ; but it is, I think, scarcely worth while to distinguish them as such. With regard to the Trap rocks, I define them as those which have been forced into sheets or dykes, but have not reached the surface. Since they may start from a mass of Plutonic rock and resemble that group, or be more nearly related to volcanoes, a preliminary subdivision is suggested into Volcanic Traps and Plutonic Traps. With regard to Ashes and Tufas they might be classed either with Volcanic or Sedimentary rocks, but appear most naturally as an independent group of the latter.

The following Table is not intended or imagined to be exhaustive, but it is hoped it may be suggestive; the great objection to it, which I do not quite see how to get over, is that it mixes all kinds of alteration together, whether due to pressure, water, or heat and water.

CLASSIFICATION PROPOSED.

Normal Rocks.		*Varieties.*	*Altered Rocks.*
Volcanic.	Acid ...	Rhyolite ...	... Felsite.
		Trachyte.	
		Sanidine Trachyte.	
		Domite.	
		Andesite ...	... Propylite.
		Augite Andesite.	
		Obsidian.	
		Pumice.	
		Phonolite.	
		Trachy-dolerite.	
	Basic ...	Dolerite ...	... Diabase.
		Nephilinite.	
		Leucitophyr.	
		Basalt	... Melaphyr.
		Ash.	
Trap.	Volcanic	Tachylite.	
		Felstone.	
		Phonolite.	
		Pitchstone.	
		Basalt.	
		Eclogite.	
	Plutonic	Elvanite.	
		Minette.	
		Kersantite.	
		Lherzolite.	

		Normal Rocks.	*Varieties.*	*Altered Rocks.*
Plutonic.	Acid	Granite.		
			Granitite.	
			Hornblendic granite.	
		Luxullianite.		
		Syenite.		
			Quartz syenite.	
	Basic	Diorite.		
		Gabbro.		
			Olivine Gabbro	Serpentine.
Sedimentary.		Sandstone		Quartzite.
		Clay		Slate.
			Marl.	
			Mudstone	Gneiss.
				Hornblende Schist.
			Sandy clay	Mica schist.
		Limestone		Dolomite.
				Crystalline Limestone.
		Coal		Graphite.

It would be too long a task to give definitions of all these; but for the sake of example we may take one of the smallest groups—the Basic Volcanic series. In this *Dolerite* is defined as a wholly crystalline mixture of *Labradorite*, *Augite*, and *Magnetite*. *Diabase* is what this rock becomes when some of the iron combines to form *Chlorite*. The varieties of Dolerite may be called *Nephelinite* and *Leucicophyr*, in which Nepheline and Leucite respectively take the place of the Felspar. *Basalt* consists of the same three minerals as *Dolerite*, but some part of it consists of an amorphous ground mass, and *Melaphyr* is what Basalt becomes when some of the iron in it forms hydrated minerals.

If this scheme were fully worked out, each rock would show its relations to others in a much more satisfactory manner than by their mere apposition in a table, and the chemical and structural peculiarities would have their due weight assigned.

A Petrographical Classification of Rocks.

By Mons. E. Renevier, F.C.G.S., &c., Professor of Geology in the Academy of Lausanne, Switzerland.

(*Communicated by* Prof. T. Rupert Jones, F.R.S., President Geol. Assoc.)

(*Read March 5th*, 1880.)

Visiting the well-ordered Museum of the Lausanne Academy in 1878, I was impressed with the practically useful arrangement which Prof. Renevier had adopted for the rock-specimens, and at my request he has favoured me with the following draft of his scheme of classification :—

ROCKS.

I. Deuterogenous.—Of secondary or derivative origin. Sedimentary, by mechanical means.
- A. Arenaceous.—Composed of sand grains visible to the eye.
  - *a*. Loose.—Gravels and Sands.
  - *b*. Consolidated.—Breccias, Conglomerates, Grits, Sandstones, Quartzite.
- B. Limaceous.—Formed of mud (*lat. limus*), more or less consolidated.
  - *a*. Earthy.—Clays, Marls, &c.
  - *b*. Schistose.—Various Non-crystalline Schists and Clay-slates.
  - *c*. Hard or Stony.—Petrosilex (?), some Quartzites.

II. Organogenous.—Sedimentary by organic means.
- A. Calcareous.—Of Zoögenous origin essentially.
  - *a*. Phanerozoic.—Nullipore-limestones, Shell-limestones, Coral-limestones, Bituminous Limestones, &c.
  - *b*. Microzoic.—Small-grained, Oölitic, and Foraminiferal Limestones, Chalk, &c.
  - *c*. Cryptozoic.—Compact, Siliceous, Dolomitic, and Crystalline Limestones.
- B. Diatomaceous (formerly " Infusorial ").
  - *a*. Siliceous.—Tripoli, &c.

b. Ferruginous.—Some Bog-iron Ore, with *Gallionella ferruginea.*

C. Carbonaceous or Combustible.—Mostly of vegetable origin.

a. Peat.

b. Fossil Coals.—Lignite, Coal, Anthracite, Graphite.

c. Fossil Resins.—Amber, Libanite, &c.

d. Bitumens.—Asphalte, Maltha, Petroleum.

III. Hydatogenous.—Of aqueous origin by chemical means.

A. Halogenous.—Formed by precipitation from sheets of sea-water, salt lakes, &c.

a. Saline.—Rock-salt, Carnallite, Nitrate of Soda, &c.

b. Gypseous.—Gypsum, Alabaster, Anhydrite.

B. Concretionary.—Formed by incrustations from mineral waters on the surface of the ground.

a. Incrustations.

1. Calcareous.—Stalagmite, Travertines, Calc-tuffs, Calcareous Alabaster, &c.

2. Ferruginous.—Hæmatites, &c.

3. Siliceous.—Geyserite, Paris Millstone (?).

b. Pisolite.—Pisolitic and Oölitic Limestones, Pisolitic Bog-iron Ore, &c.

c. Nodules.—Argillo-calcareous, Ferruginous, Flint, Hornstone, Jasper, Agate, Pyritous, and Carbonate of Iron (Sphærosiderite) Nodules.

C. Spathic or Veinstuff.—Formed by hydatogenous crystallization in subterranean fissures under pressure. Various gangues of Calcspar, Spathic Iron-ore, Heavy-spar, Fluor-spar, Quartz, &c.

IV. Pyrogenous.—Of chemical origin by means of fire.

A. Lavas.—By the cooling of molten matters.

a. Trachytic.—Principally Alkaline Silicates of Alumina: Trachyte, Phonolite, Pumice, Perlite, Obsidian (Trachytic), Pitchstone.

b. Basaltic.—Magnesian Silicates: Basalt, Dolerite, Melaphyre.

c. Euritic.—Alkaline Alumino-silicates, with an excess of silica.

Eurite (Felsitic), Pitchstone, Euritic and Quartziferous Porphyries.

d. Dioritic.—Magnesian Silicates, with excess of silica. Aphanite, Amygdaloid, Diorite, Dioritic Porphyry, Variolites (?).

B. Volcanic Aggregates.—Formed of solid *débris* ejected from volcanoes.

a. Loose.—Papilli, Volcanic Sand, Ashes.

b. Agglomerated.—Volcanic Breccias and Tuffs, Peperino, Trass, Wacké, Domite (?), Argillophyce (?).

V. Cryptogenous or Crystalline.—Of doubtful origin, its evidences having been obliterated by crystallization.

A. Crystalline Schists.

a. Alumino-alkaline.—Gneiss, Mica-schists, Felsite.

b. Magnesian.—Chloritic Schists, Talc-schists, Serpentine, Amphibolitic Schists.

B. Granitic or Massive Crystalline.

a. Granites.—Granite, Granitite, Protogine, Pegmatite, Greisen.

b. Amphibolitic Massives.—Syenite, Euphotide, &c.

This is the general plan adopted by Prof. Renevier. On some points he is not quite satisfied, and is open to receive suggestions for improvement. He observes that this classification follows that given by Lyell, according to the *origin* of rocks, but avoiding reference to the known or supposed *succession* of rocks.

Prof. Renevier has published a large and well-known Stratigraphical Table of the Geological Formations.

On the Geology and Physical Features of the Bagshot District.

By Professor T. Rupert Jones, F.R.S., President of the Geologists' Association, &c.

(Read May 7th, 1880.)

CONTENTS.

§ 1. *Area.*—The sands and clays of the group of Tertiary strata known as the "Bagshot* Sands" occupy in the Bagshot district an area of about 300 square miles, extending about 24 miles from Esher on the east to Winchfield on the west, and 12 miles from Ascot on the north to Aldershot on the south; and they reach an altitude of about 400 feet above the sea-level. In other words, this division of the Lower Tertiaries is well developed in those parts of Hampshire, Berkshire, Surrey, and Middlesex that lie between the Chalk ranges of the Hog's-back and the Surrey Hills on one side, and the line of the Thames on the other, with the Chalk ranges of Berks and Buckinghamshire parallel to it.

The hill-ranges of Easthampstead Plain, the Chobham Ridges, Finchampstead Ridges, and the Fox Hills, separated by the Blackwater from the Hartford-bridge Flats, which extend westward in the direction of Odiham and Basingstoke, are all composed of the "Bagshot Sands." These strata lie on "London Clay,"

* Bagshot, a hamlet of Windlesham, was brought to notice as a posting station on the main road from London to Salisbury and the West.

resting on "Woolwich and Reading Beds," below which is Chalk, in a broad shallow "syncline." Gravel coats the tops of the hills, fringes the hillsides here and there, and covers the valley-bottoms at various levels.

§ 2. *Features.*—This country of the Bagshot Sands mainly consists of flat-topped hill-ranges or small plateaux, formed of sandy strata, with gravelly tops. Along their edges they are cut into frequent gullies and spurs, sloping downward quickly into valleys. These are narrow at their upper sources, where they leave the hill-land, and broad and shallow below, where they reach the river-lines. Thus they open into the wide valleys of the Wey, Blackwater, and Loddon, to which they bring tributary streamlets; and all merge into the greater valley of the Thames.

The district is not rich with fossils, nor free to expose many geological charms in quarries or other sections; but its physiography is very interesting.* Looking around from the floors of many of the valleys, we can readily discern the main feature of the area, characteristically marked by the long line of level crest all around, standing out against the sky. Even where the hill-tops (as frequently occurs) are crowned with pine-woods (the only trees finding congenial soil for full development), the same general level of the *terrain* is apparent; and, indeed, the evident general levelness of the upper line of the country cannot fail to be striking to the intelligent observer.

The flat hill-tops keep their long level edge-lines, because of the harder gravel and seams of sand, closely cemented by iron-rust, which protect the weaker materials below. The more prominent spurs and other marked features of the landscape, with their regular slopes and elegant outlines, are due to the existence of this "pan," which lies from 3 to 12 feet below the platform. The formation of this irony layer was caused by water lodging here and there on the once-continuous gravel plain (since cut into separate hills and ridges), and carrying the iron-oxide downwards by percolation to the first impervious layer, which is often the underlying sand itself "puddled," or made water-tight, by the ferruginous cement filling its pores and interstices. Similar "pan" or "rust" also underlies the gravelly surface in the valleys at many places.

* See also Proceed. Geol. Assoc., Vol. vi. p. 329, &c.

Along the borders of the main hill-ranges, or more strongly marked table-lands, there are many outlying hills and "under-features," consisting of similar sandy materials. Those on the outside of the area are based on the London Clay. Those within the area consist of Upper, or of Middle Bagshot Sands, as the case may be. Some of these "outliers" reach the level of the plateau-gravel, and retain a capping of it, hardened and preserved by the irony "pan." Others, at a lower level, have bare sand tops; others bear valley-gravel at different levels, according to position.

§ 3. *Flora and Fauna.*—Vegetation is not luxuriant, as far as diversity of plants is concerned. The up-land bears Fir-trees, Furze (Gorse or Whin), Heath, and Whortleberry as its chief plants.* The low-land, lying nearer the clay, and therefore more silty or loamy, and better supplied with water, contains a more varied flora. In these hollows much of the land is boggy. Thus the long Marsh-grasses, the Bog-moss, the Bog-myrtle, Cross-leaved Heath, Cotton-grass, Kingspear, Sun-dew, and Alder find congenial sites, with smaller and less noticeable vegetation, in these parts. Still lower down, in wider valleys and in stiffer soil, the Oak and Elm attain their normal proportions.

SOME COMMON HEATH PLANTS.

Ulex europæus, Common Furze ... ... Ulex nanus, Dwarf Furze ... ... Genista anglica, Petty Whin	Chiefly on the lines of roads or paths, but sometimes on the tops of hills.
Sarothamnus scoparius, Common Broom	Road-sides.
Erica tetralix, Four-leaved Heath ...	Abundant (in dampish places).
Erica cinerea, Ashy Heath	More abundant (on the Heaths).
Calluna vulgaris, Scotch Heather ...	Most abundant (do.)
Myrica gale, Bog-myrtle	Swampy parts of Heaths, along the edges of streams or ponds.
Drosera rotundifolia, Round-leaved Sundew Drosera longifolia, Long-leaved Sundew	Wet Bogs.
Pedicularis sylvatica, Common Lousewort Polygala vulgaris, Milkwort	Damp parts of Heaths.

* See Kingsley's "Miscellanies" (My Winter Garden), Vol. ii, p. 140, &c.

Habenaria alba, Butterfly-orchis ...	Marshy ground round Hawley Pond.
Juncus bufonius, Toad-rush ... ... Juncus squarrosus, Heath-rush ... ... Carex distans, Distant Carex	Damp Heaths.
Mollinea cærulea, Purple Mollinea ...	Everywhere in the low grounds.
Agrostis setacea, Bents ... ... Nardus stricta, Mat-grass	By the sides of all heath paths or tracks, especially in marshy parts.

Sphagnum, Lycopodium, and Equisetum are found in the Bogs and Ponds.

[A. H. CLAYPOLE.]

Many birds inhabit the district. In a short walk through some plantations (chiefly fir) in one of the valleys, the late S. P. Woodward recognized the notes of more than a dozen kinds in an afternoon of June. The magpie, jay, and woodpecker are still not uncommon, in spite of the destructive gamekeeper. A pair of hawks are sometimes seen. Squirrels and hedgehogs, grass-snakes, vipers, slow-worms, and lizards are common, the *Coronella* snake seems to be rare, but perhaps is frequently killed in mistake for the others; frogs and toads are common, and young toads swarm over the paths and roads of the woods and heaths near water in the spring. The fauna and flora of this part of the country is carefully tabulated in the Annual Reports of the Wellington College Natural Science Society.

§ 4. *Water-supply and Drainage.*—The streams, which have their channels in the larger valleys, are fed by the streamlets formed by water leaking from the gravelly tops and sandy sides of the hills. Such upland lines of drainage are marked in summer by long verdant stretches of luxuriant marsh-grasses, the apex of the outdrawn bright-green triangle pointing up to the spring or leakage in the gravel above, on the edge of the plateau, and the base widening out over the narrow marshy valley at the hill's foot. In winter, the grassy verdure is replaced by light-brown, dry, coarse hay; to be again renewed in spring and summer.

The rainfall is about 23 inches a year; and the water is largely stored in the gravels and sand-beds for the permanent springs; and the peaty patches of the higher valleys help in the storage of water to supply the amount carried down by the rivers.

Thus the water-supply and, therefore, the river-drainage wholly depend on rainfall, ruled by the geological structure of the area.

Wells are supplied with water at different levels. There are shallow wells in the gravels. Others, sunk to Middle-Bagshot beds, which are clayish, have a much better supply, especially when near the lakes which lie at that level. A deeper sinking pierces the lower sands, full of water, on the London Clay. Only a few borings are driven through this thick clay to the still better water-bearing Woolwich Sands and the Chalk beneath.*

§ 5. *Geological Structure.*—This structure may be briefly defined as plateaux, hills, and valleys cut out of flat layers of—1, Gravel (glacial); 2, Bagshot Sand, Clay, and Sand (Eocene); resting on, 3, London Clays; on 4, Woolwich Sands and Clays; and on 5, Chalk.

On the valley-sides, moreover, are benches and terraces of high-level and low-level valley-gravels.

The following is a general section of the strata†:—

1.	Gravel, with loam	12 feet.
2.	Upper Bagshot Sands, with Sarsden Stones in place, and some thin seams of irony loam, occasionally fossiliferous, with Turritella, Natica, Cardium, Ostrea, Nummulites, &c.	150 feet.
	Middle Bagshot Sands, with argillaceous,‡ and lignitiferous beds, some pyrites and fossils, *Cardita planicosta*, &c. ...	50 feet.
	Lower Bagshot Sands	100 feet.
3.	London Clay	400 feet.
4.	Woolwich and Reading Series	65 feet.
5.	Chalk	600 feet or more.
	(Seen outside the district, and reached in it by boring.)	

Below all these lie the Gault, about 100 feet thick, and the Lower Greensand (or Neocomian Sand), about 800 feet, &c.

* Such as the deep well at Wokingham, lately described in the "Geol. Mag." Ser 2, Vol. vii, p. 421.

† For details, see Prof. Prestwich's Memoir in the "Quart. Journ. Geol. Soc.," Vol. iii, p. 378; and Whitaker and others in the "Memoirs Geol. Survey," Vol. iv, p. 308, &c.

‡ Some of these are loamy sands, the sand being mixed with a slight quantity of clay; and this latter, being sometimes in very small scattered lumps, shows that it was derivative, and that intermediate erosions had taken place during the deposition of this series. Hence evidence of great lapse of time, and possibly of imperfect record.

Though there are not any considerable sections exposed in the area under notice, the above estimates can be fairly gathered from the neighbouring railway-cuttings and other sections, as well as by the deep wells made, of late years, at Bearwood, Wellington College, Wokingham, and elsewhere, and by the old wells in the neighbourhood of the villages, as far as their evidence goes.

The sides of the valleys take their characters from the conditions of outcrop of the successive horizontal beds; the parallel contours being approximately equal to the lines of outcrop. From this circumstance the nature of distant hill-sides, whether on the near or the far face of the hill, can be inferred from the nature of any one hill.

The heads of many of the valleys are separated, one from another, by low "cols"; and there are many "under-features," or nearly isolated low outliers, caused by the unequal degradation of the spurs by weather and rain-action, or held up by high- or low-level valley-gravels, according to the local distribution of these materials, forming benches or terraces.

Thus the gravel edges, especially at the crest of the hills, are, as a rule, steep, and give out water; the sand slopes are much more gentle, and give some water, though not so much in proportion as the gravel; and the clay bottoms, which are nearly flat, or have only a slight inclination, have always a wet surface, as the spring- and rain-water settling on them, without soaking in, finds its way to lower levels.

The strata constituting the district are practically flat; but theoretically they are synclinal, being turned up at their north and south edges, together with the underlying Chalk, Gault, and Greensand, as seen in the chalk-pits and other sections near Guildford, Tongham, &c. Thus they form part of the so-called "London Basin" (really a trough), which, with the anticlinal ridge of Wilts, &c., as a complement, is conterminous with the syncline of Hants and the Isle of Wight.

a. It cannot be too often pointed out that the Bagshot-Sand series of this neighbourhood is one that teaches the broader lessons of physical geology rather than stratification or palæontology. It teaches these physical results in the modern configuration of the ground, and, therefore, it is useful in directing the observer's eye to alterations and changes in other formations, which have followed the same laws.

Some of the Upper and Middle Bagshot Sands, however, show

many interesting fossils, mostly of a molluscous nature. False-bedding, the result of wind and tide action, are in some places well represented. Except in certain beds, fossils are rare, and, as a rule, in the state of casts; for the water, percolating easily between the particles of sand, has been able to get at the shell-matter and dissolve and remove it. No modern sand-bank is rich in animal life, at least as residents. Sand-banks are, as a rule, shoals, or lie in shallow water, where wave-wash and trituration by sand must be agreeable to few creatures unless "to the manner born." Shells are thus easily removed and broken; and, if broken, more easily dissolved and destroyed than in the quieter waters of greater depths, where the mud and finer particles have found rest.

Casts of *Turritella*, *Natica*, *Calyptræa*, *Cardita*, *Cardium*, *Pectunculus*, *Lucina*, &c., are found at several spots:—Near "Cæsar's Camp," on Easthampstead Plain; near the Criminal Lunatic Asylum of Broadmoor; on the Windsor Ride near the Royal Military College; by Hawley Pond; along the road by Long Cross, near Windlesham; and elsewhere.

In excavating a well at Wellington College, several fossils of the above kinds were found, and a seam with *Ostrea* and *Nummulites lævigatus* was passed through. So also at Woking Nummulites were brought up from the well at the County Lunatic Asylum.

These are sufficient to prove the geological horizon and age of these strata.

The Upper Bagshot Sands contain little or no clay.

b. The middle set of strata which appear at the bottoms of some of the lower valleys hereabouts are much more loamy and greenish.

As the oxide of iron in the common yellow sands of the Bagshot series undergoes a chemical change in the presence of stagnant water with decomposing organic matter in it, and becomes green (drying to a greenish-grey), it is difficult sometimes to discriminate at first sight between real green "Bagshot" and the greenish loamy and silty sand of some of the drainage lines leading towards the streams. By the presence of glauconite in the real "Bagshot," as well as by the position of the successive beds, the distinction can be made. Some, however, of the Middle Bagshots, in which there is much vegetable matter, may have received their green tints partly or wholly from the peculiar oxidation of the iron above referred to.

At Bagshot and near Sandhurst the Middle Bagshots are

exposed, and their loamy beds are sometimes used for brick-making. Close to the railway-station at Wellington College, the railroad is continually wet with the rain-water which percolates the thin sand over these clays, and weeps out on their surface where exposed by the cutting. The Middle Bagshots are best seen in the well-known cutting of Goldworthy Hill, not far from Woking, on the South-Western Railway.

c. The Lower Bagshots are visible near Wokingham and Virginia Water; also between Woking and Weybridge; at Ash, Aldershot, and elsewhere. They consist of yellow sands, and rest on the London Clay, as can be seen near Weybridge, Aldershot, Wokingham, Sunningdale, and elsewhere. Resting on this impervious clay, they form a good reservoir of water; but the water is not everywhere good, for it is often contaminated by the pyrites of the clay giving off sulphurous salts and iron.

Near the exposed junction of this sand with the London Clay, it often thins out over the latter, owing to the slope of denudation and the lie of the beds. In this case it is better timbered than where the sands are thick; for the trees have a firmer soil and more water. The clay grounds can be readily distinguished by the vegetation of their surface; for the eye recognizes at once better herbage, finer crops, and a free growth of oak and elm.

The recognition of the presence of hard clay under an out-thinning edge of similar sands in the New Forest, Hampshire, enabled the late Mr. Menzies, when a young man, to account for the stag-heading and decay of trees, which had long puzzled older heads than his.

d. Sarsden Stones.—In the Upper Bagshot Sands are numerous blocks of fine-grained, compact, white sandstone, lying not far apart one from another, along one horizon (near the surface of the Frimley Ridges, for instance); and, doubtless, once occurring as far as these Upper Sands extended. They are roughly oblong, about 12 feet long, and less; rounded below, flatter, usually, above; with a friable and ferruginous exterior where they meet the sands in which they are imbedded. They are evidently portions of the sands consolidated locally by siliceous cement; but how the silex became dissolved and reset is a very difficult question, not yet solved. These stones, in many instances, have been freed from their sandy matrix, and lie in the derivative gravels, in either a slightly or much worn state. Some have become more ferruginous and friable; some retain

their internal hardness. Several show traces of the rootlets and thin stems originally enclosed in the sand; some (possibly from a little distance) contain flint-fragments. Occasionally the weathering has dissected them so far as to show a decided concretionary structure, to which also their convexity, or roughly lenticular shape, has reference. Elsewhere these stones lie about on the surface of the country in large quantities, and have been called "grey wethers," since they look like sheep; and by the older name of "Sarsdens," supposed by the late Rev. J. Adams to be of Saxon origin, meaning "sair" (sore, troublesome), "stanes" (stones), as, indeed, they were to early settlers and cultivators of the soil. These stones are also called "Sarsen" or "Sassen," equivalent to the Saxon "Sesan," stones ("R. F.," in "Geological Magazine," 1874).

The bibliography of these Tertiary concretionary blocks is extensive. Much information about them, with references to writers on them, will be found in the "Quart. Journ. Geol. Soc.," vol. x, p. 123; vol. xviii, p. 271; "Memoirs Geol. Surv.," vol. iv, p. 193; "Geol. Mag.," vol. iii, p. 296; vol. x, p. 200; "Geol. Mag.," n.s., vol. i, p. 96; vol. ii, p. 588; "Mag. Wilts Arch. N. H. Soc." (Codrington), 1865; "Transact. Newbury Field Club," vol. i, p. 107; vol. ii, p. 248; "Journ. Proc. Winchester Sc. and Lit. Soc.," vol. i, part 4, 1874.

These Sarsdens are sought for with an iron rod on the Frimley Ridges, and when found are exposed by digging, and broken up into small square stones for paving or building. The deserted holes are dangerous pitfalls for man and beast. Large specimens found in the gravels of railway-cuttings are similarly broken up, dressed, and used for pitching or masonry. Being dense siliceous sandstone, or quartzite, they are very lasting.

§ 6. *Geological History of the District.*—We now turn to the geological history of the Bagshot District.

1. The Bagshot Sands are the shallow-water and western equivalents of the great Nummulitic Formation, which is represented in the east by the thick Nummulite-limestones, deposited in the open ocean of the period. Having been laid down by the Early Tertiary (Eocene) seas, and perhaps overlaid with deposits equivalent to the Fluviomarine series of the Isle of Wight (of which beds, however, no traces remain hereabouts), they partook of the great undulatory and crushing movement of the crust of the earth, which reached, with greater and greater folds, far away

into the Alpine region of Europe; and they were left in the synclinal position above referred to, the Chalk and strata beneath being also bent in the same great hollow curve, and equally sharing in the crush and crumpling with the superincumbent strata.

2. The great arches of these undulated strata were doubtlessly subjected to wave-action as they rose to the sea-level; and they have been destroyed down to the Chalk and the strata far below it, as seen in the Wealden area. Those Tertiary beds which were let down into the hollow curves of the London and Hampshire districts, respectively, have not wholly escaped destruction, for they have been greatly denuded. The Chalk, being homogeneous and relatively hard, has kept its outcrop at a higher level than the soft Tertiary sands and clays, even 800 feet above the present sea-level in some of the Downs; and here and there the ferruginous and cherty sandstones of the Neocomian and Wealden series have hills of equal height; thus indicating, according to Prof. Ramsay, an old plain of marine denudation, whilst the lower flats, cut out of Tertiary material, would be a second plain of like origin; but, according to the views of other geologists, these plains represent the average local level left by the wear and tear of ordinary atmospheric denudation (even without sea-action) on strata of average consistencies.

The soft sub-Cretaceous clays and sands, on one hand, have been worn away deeply into the complex valley-system of the Wealds of Kent, Surrey, and Sussex; and, on the other, the London and Hampshire Tertiary areas have each its own system of flat-topped hills and divergent valleys, worked out from a gravel-capped plateau, of much less elevation (about 400 feet) than the bordering Chalk hills (about 800 feet).

How far sea-action, with waves, and how far weather-action, with frost, snow, and rain, have severally operated in reducing the South-east of England to its present levels, it is difficult to define.

3. It is not, however, the Tertiary Sands that form the actual surface of the Bagshot District, but certain Gravels, which have been referred to as coating the plateaux and hill-tops. The denudation, or wearing away, of the surface of the disturbed Tertiary and Cretaceous strata (perhaps then not quite at rest from oscillation) was probably effected by slow marine erosion in the Later Pliocene Period, when the northern area of what is now the British Islands was under an arctic sea, with periodical coast-ice, and probably frequent ice-floes and icebergs. The shallow waters

of this more southern district did their wave-work, with storms and winter-ice; and, having planed down the comparatively resisting cliffs and shoals, they ultimately left the area between Chalk hills of Surrey and Bucks, and of Sussex and Picardy, bestrewn with the wreck of denudation. Whatever younger beds of Tertiary date (Upper-Eocene or Oligocene) may have originally overlain the "Bagshot Sands," these latter at one time, being bared and worn down, were part if not of the Pliocene, certainly of the Post-tertiary sea-bottom, whether formed in a shallow sea, or in wide estuarine flats, loaded with shingle (gravel) and mud (loam).

The gravel consists chiefly of subangular flints from the Chalk, with Tertiary pebbles (usually dark in colour); there is also a large percentage of chert from the Neocomian sands of South Surrey, a free sprinkling of quartz* in small pebbles (rarely so large as a thrush's egg), and occasional large blocks of concretional sandstone from the Bagshot Sand.

The railway-cutting through Portesbury or Crawley Hill gives a section of a part of a Post-tertiary bank, limiting the plateau-gravel against a water-worn slope of the Upper Bagshot Sand.

4. When the erosive, abrading, or denuding action began to lose its power the currents ceased to remove all the detritus which the waves had made; and the fragments of the harder rocks were left in greater or less profusion over the surface. Thus the broken and partially rolled (and even raw and unworn) flints from the Chalk, which cropped out along the borders of this Bagshot area, and even fragments of the southern chert-beds of the Neocomian Sands beyond, were dispersed on banks and shoals, and mixed with pebbles from the Lower Eocene pebble-beds lying on the Chalk and exposed with it along its out-crop. The "Bagshot Sands" of some parts of the area supplied also quantities of sand and loam, and many "Sarsens." Shifted here and there by changeable currents and coast ice, sorted in one place, massed together in another, and worked upon sometimes by floating ice, gravel coated the flats, formed a nearly continuous level, and, together with the adjoining higher lines of Chalk, was ultimately deserted by the sea, either from slow upheaval, or by the retiring of the water, the quiet flood-waters or gentle tides leaving loam at the last. This completion of the high-level

* Derived, probably at second-hand, from old wreckage of the primæval land once lying to the west of the Bagshot area.

gravel-flats may be looked upon as a special datum-level in the history of the Bagshot District.

4. As this extensive gravel-flat or sub-marine plain came nearer to the surface, and finally appeared above it, the shallowing water, becoming sea-creeks, ate out the rising plateau, with the aid of winter-ice, and roughly carved out the present valleys. Then sub-aerial agencies took part in the further alteration of their features. The valleys were deepened and widened by rain and snow. The heavy rainfall of the Pluvial Period, with its fierce storms, not only cut out the spurs and ridges more definitely, but formed lakes, in the lines of drainage, having gravel lips or beaches which were to be the benches and terraces of the valley-gravels at different levels, as we now see them.

Certain portions of the plateau-gravel obstinately resisted denudation, being fortified by the hard, compact, ferruginous character of its lower layer.* Hence, probably, limits were set here and there to the destruction of the plateau; and decidedly certain spots so well opposed the abrasive action going on around, that they figure as conical, and almost isolated, hills at the present day. Such are the Obelisk Hill at Camberley, and Edgebarrow Hill, near Sandhurst.†

These layers of irony sand and gravel are not limited to the bottom, but occur here and there in the mass of the gravel, wherever water, percolating downwards, met with or made impervious layers, choked or "puddled" with iron-oxide. Such infiltered oxide occurs in gravels at many levels over the district; wherever water brings the oxide from higher grounds to soak into the superficial gravel. At Windlesham the rust takes the form of bog-iron-ore, six inches thick, under peat, on clay, where gravel is absent.

A point of much interest is the occurrence of this "pan" (as it is called) in the plateau-gravel, in the limited spots, now defined in some cases by the circumdenudation of conical hills. Water must have collected and lain in certain hollows, and accumulated the ferruginous matter by percolation, before the cutting-out of gullies and valleys destroyed the old flat, or high plain. It may have been some of the sea-water whilst retreating, or it may have been long-standing fresh-water in an interval of great duration.

In both sets of gravel (that of the plateaux and that of the

* See "Proc. Geol. Assoc.," Vol. vi, p. 208.
† See "Proc. Geol. Assoc.," Vol. vi, p. 334.

valleys) we find numerous Sarsens, or blocks of compact sandstone, derived from the Upper Bagshot Sand. They are broken and water-worn; but those in the Low-level Gravel to a much greater extent than those in the higher gravel. The breaking-up of these masses (in their native matrix of the Frimley Ridges, sometimes 12 feet long, by five, and two feet thick) may have been due to frost rather than to violence; but the surfaces bear evidence of having been slowly worn by sand and pebbles washed over them persistently, worrying out cup-shaped hollows and funnel-like holes, especially where the small trumpet-shaped apertures of the tubes, due to the congenital root-marks, or the ends of small stems on fractured faces, presented depressions suitable for the erosive action of eddying sand and water. In some instances a highly glazed surface occurs on the stones, due to the polishing action of blown sand. As this latter operation must take place on a shore or shoal above the water-level, and yet these stones have been imbedded in strata laid-down by water, we have here, as elsewhere, indications of a lapse of time, while the several natural operations were taking place, with intermediate oscillation of level, though possibly only of the local sand-banks and beach-lines.

Neither the plateau-gravels nor those at lower levels in the neighbourhood of Bagshot and Sandhurst have as yet furnished any fossils, except those in the flints derived from the Chalk, and the sponge-spicules in the Neocomian chert. No mammalian bones nor stone-weapons of Archaic Man have been yet met with in the high-level valley-gravels here as they have elsewhere been found in the Thames Valley, at Reading, and lower down by London. The low-level valley-gravel is also barren here, though rich with remains of wild animals, and not destitute of human relics, in the valleys of the Kennet and Thames. In the latest deposits of silt and sand, however, in the deserted bed of one of the affluents of the Blackwater, namely, along a branch of the Wish, just within the Surrey boundary, and within a few hundred yards of the Staff College, flint-flakes and implements have been left by Prehistoric Man.

To return to the history of the Gravel of the Valleys. When the estuarine or partly lacustrine waters drained away as the land slowly rose (or the water sank), when the land was, as it well may have been, shoals and variable islets, the wash and swirl of tide and storm must have been the first instruments in roughly carving-out the present features. Floods and pack-ice of hard winters would

account for many of the evenly-scooped valleys, and, still more, for the presence of the lower-level gravel, irregularly scattered at various elevations. These gravelly benches, showing where the waters rested for a time, lie at equal, or nearly equal, levels on the sides of the greater valleys. Between the Blackwater River and the summit of the Chobham Ridges, three distinct levels or benches occur, where the gravel thus rests; and these must have been deposited there by a more powerful agency than ordinary rains and floods of the present day. The gravel is of the same character as that on the high level, that is, somewhat water-worn, or subangular, not pebble-like in character, only having some Tertiary pebbles mixed with it. Much-worn fragments of "Sarsens" and chert are also present. Except at a few spots, this gravel is paler and looser than the higher gravel, having less iron-oxide in it; this material having been largely washed out during the rearrangement of the gravels.

Such a bench or terrace of gravel is particularly apparent at Camberley, a little above the Railway-station, at and behind the Staff College, and along the 270 feet contour round the spurs of the plateau. Yorktown Church also stands on an outlier of this terrace. A gravel of lower level is worked for road-metal in the Frimley Road, near Yorktown, and its terrace crosses Yorktown. These have corresponding terraces, at nearly the same levels, on the other side of the Black water, on the sloperising to Hartford-bridge Flats.

In relation to the higher valley-gravels, there are some patches that seem to have a somewhat different origin. Near the Obelisk Hill, for instance, which is a small isolated conical hill, owing its shape to a very tough band of pan-ironstone, and which stands out from the spurs descending from Easthampstead Plain, is a gravel-bed lying in the bend between the hill and the neighbouring spurs of Diamond and Portesbury* or Crawley Hills. It is difficult to imagine how this came to be deposited, unless we suppose (as suggested by my friend Capt. C. C. King, F.G.S.) the neighbouring slopes, then shoals, just "a-wash," to have been covered by stranded pack-ice, which, having carried off masses of plateau-gravel from the cliff of the upper part of the creek, had floated them into deeper water, to be stranded against Obelisk Hill, where they melted. Near Hawley, on the west side of the Blackwater, the same thing

* I regret not having examined this "bury" for earthworks before the railway was cut through it. A groat of Edward II. was found here when the cutting was first made, about ten years since.

seems to have occurred; for an isolated patch of red gravel has been placed there, probably by floating ice, which, escaping from the obstacle of Obelisk Hill, had been swept down the valley to the west by the same prevalent easterly wind.

Other slighter patches that here and there coat the hillsides were probably caused by the mere wash of wind and tide under ordinary circumstances of weather; the stormy spring winds from the north-east probably leaving the strongest marks on the western slopes.

These gravels, then, are important in giving shape to the land, and character to its vegetation. The scanty-soiled hilltops, with their impervious band of "pan," only afford subsistence to the fir-trees and heather. Tap-rooted trees grow badly there; and the experienced physical-geologist would see without excavation that that condition was due to want of depth of even a sand-soil, and though to insufficiency of water in general, yet also to its over-abundance at times, making a swampy turf. The rain-water fails to penetrate the "pan," and weeps out at a definite level along the hillsides, at the edge of the plateau—a level marked by the head of a widening train of coarse marsh-grass down the slopes, and a relatively more luxuriant vegetation. These lines of water-issue, we may reasonably assume, have to a considerable degree helped to modify the hill-features, which had been roughly carved out by the retreating sea and by the floating winter-ice.* Not only does rain-water, running over the exposed edge of hard "pan" hollow out the sand below, but water, issuing below the gravel, brings with it, when in force, so much sand that the hard beds are undermined, and fall bit by bit at the valley-head.

We must, however, ask for greater water-power, compared with that of to-day, to have existed formerly—whether as rain or snow-floods, for the excavation of such upper valleys, mere *cul-de-sacs,* with heavy coverings of large flints, as that between Crawley and Diamond Hills, and that opening into Wishmoor on the other side of Diamond Hill. The latter short valley seems also to have been sufficiently full of water to have received a deposit of silt and sand 18 inches thick, in which flint-flakes and implements are found (as above mentioned), pointing to former occupation by Prehistoric Man.†

* Since writing this paper I have seen a very interesting and suggestive paper, on the geology of the Sandhurst district, by the Rev. Alex. Irving, B.Sc., F.G.S., in the "Sandhurst Parish Magazine," 1880.

† See "Proc. Geol. Assoc.," Vol. vi, p. 329; and "Journal Anthropological Institute," Vol. ii, p. 365.

§ 7. *Antiquities.*—Of later date than the Flint-implement Station above mentioned, the traces of successive occupation of the hill and valley-lands are numerous about this district. The track-ways, at places *hollow*, converging from the east on the old ford over the river at what was once known as Broadford, subsequently as Blackwater Ford, and Bridge, and now as Blackwater, are numerous and deeply worn.

They occur on both sides of the intervening hills, as Obelisk Hill at Camberley, and Osnaburgh Hill in Yorktown. Near these old lines of route were probably many halting-places, especially where the side-tracks entered the main east and west artery of traffic or of passage. There the British nomad re-fashioned and re-chipped his arrow-heads and celts of flint. Thus at the above-mentioned stone-station, near the Staff College, on the little stream draining into Wishmoor,* also in the gardens of the Royal Military College Terrace, bordering the lower part of the Wishmoor stream, and in the neighbouring part of Yorktown, at the old ford-ways near Sign Farm (Frimley), near the church at Sandhurst, and in the grounds of Wellington College, flint-flakes, more or less dressed and used, have been found in varying quantities. Outside our particular district, flakes and implements have been gathered along the northern slopes of the Hogsback, overlooking this area, as at Wanborough; also at Seale and Puttenham, on the south side; and further away, at Greywell and Wanborough, near Odiham.

A small cinerary urn (British or Brit-Roman) and some fragments of similar pottery, have been found at a gravel-pit on the Frimley Road, near Yorktown. Here a Low-level gravel forms a slight rise, marked by a small group of cottages, above the marshy ground of the lower part of the Camberley Valley, and has been evidently the site of an old occupation, on the south side of a pond made by damming the little stream. This was called Prance or French Pond on old maps; and has been completely drained within the last fifty years.

The Bagshot District still possesses some prehistoric tumuli of the great men of their day:—

On Easthampstead Plain, near Wickham Bushes, in Easthampstead Park, near Woden's Hill, and again on the Hartford-bridge

* This is an ancient name, meaning the *great drink-water*; see Mr Buckley's remark at page 365 of the "Journal Anthropological Institute," Vol. ii., 1873.

Flats, near Minley, where a fine polished celt (now in the possession of Mr. Raikes Currie) was found in what appears to have been a primary interment, with ashes and burnt bones, near the site of Minley Church. One large tumulus on Hartford-bridge Flats was opened many years ago, and the urn (?) is said to have been taken to Hugenden in Bucks by Mr. Norris, who had had the mound examined.

With these indications of early life may be classed the British Camp and the Roman Road described by the Rev. A. Irving and Capt. C. C. King in the "Proceed. Geol. Assoc.," Vol. vi, p. 331, &c. The earthworks overlook Bracknell, and is known as "Cæsar's Camp."*

After these come traces of Roman or Brit-Roman life in the old Station at Wickham Bushes, with its British and Romano-British pottery, tiles, and coins.† This clearing, with its close smooth turf and ancient hawthorn trees, in the depth of the pine-wood, has its counterpart in another and similar spot further eastward, which has, however, yielded no remains.

The Roman Road, altered in name to the "Devil's Highway," and uniting Silchester (Calleva Attrebatum) with Staines (Pontes), runs not far from this old village of Wickham Bushes, the derivation of which from *Vicus* is sufficiently evident. Near this same road, "on property now called Broom Hall, which is about a mile east of Charter's Pond, and near Sunningdale Station,"‡ the ancient marble statue of a Roman warrior (Emperor ?) now in Mr. Waterer's garden at Bagshot, was found. It may have been left there on its way from the landing-place at Staines to decorate the Forum of Calleva, when the Saxon raid, which destroyed that seat of Roman Power, swept by. Roman remains have been recorded from Hadley or Rapley's Farm and elsewhere on the old highway to the eastward towards Staines.

* In his "Itinerarium Curiosum," &c., 1724 fol. London, p. 169 (Iter vii.), Dr. W. Stukely wrote as follows;—"Upon the great moor between Bagshot and Okingham, near East-hamstead park, we saw a large camp upon a hill, doubly ditch'd, commonly call'd *Cæsar's* camp, as many more, without any reason. There has been a well in it, and both *roman* and *british* coyns have been found there—one of Cunobelin in silver. Its figure is not regular, but conformable to the top of the hill. Near it are two large barrows, Ambury and Edgbury."

† See "Work at Wickham Bushes" in the "Tenth Annual Report of the Wellington College Nat. Sci. Soc.," 1880, p. 90, with four plates.

‡ John Waterer, Esq., has favoured us with this information.

Lastly, traces of a later and less interesting history are coupled with the name of Bagshot Heath.

Hangman's Clump, Gibbett Hill, Gallow's Lane, and Gallow's Stem (the site of an old gallows, a portion of which stood till of late years) all point to the time when travelling from London to Southampton and Salisbury was a journey of no mean danger, or at least, of anxiety, thanks to Turpin and his gang—one of whose most notorious haunts was the ancient "Golden Farmer" public-house, near the modern "Jolly Farmer" inn, at the junction of the Portsmouth and Southampton Roads, a mile west of Bagshot.

Note.—According to a map constructed by the Officers of the Senior Department of the Royal Military College in 1836, the Roman road from Silchester (Calleva Attrebatum) to the Bridges at Staines (Pontes) entered the Bagshot area at the west of the Finchamstead district, crossing the Blackwater at Thatcher's Ford, and passing through West Court to Crowthorne. From this it was continued in a perfectly straight line over Easthamstead Plain, and between the two westernmost of the four or five ponds which lie south of Rapley Farm to Duke's Hill. In rising over the western spur of the plateau, a small road diverges from Lodge Hill to "Wickham Bushes," returning to the main road at the eastern side of the plain. Where it passed between the ponds at Rapley the water, either by neglect or by design, has been allowed to cut through the roadway, thus forming one pond instead of two. At both Rapley Farm and Duke's Hill Roman and Romano-British pottery has been found.

From Duke's Hill the road ran direct to a small island in the Thames, lying about one-third of a mile north of the present bridge, and about one-eighth of a mile south of "London stone." As this passage must have been effected by *two* bridges, the origin of the name of "Pontes" is distinctly traceable. In its course the road touched the southern end of Charter's Pond, and passed over what is now the southern creek of Virginia Water, which lies west of the Wheatsheaf Inn, through the yard of which inn it also passed. Foundations have been found there, with bricks and pottery. Similar remains were also found at Bakeham House, further on.—C. C. King.

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